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ORIGINAL ARTICLES.

I.—A Note on the Geology of Somali-land, based on Collections made by Mrs. E. Lort-Phillips, Miss Edith Cole, and Mr. G. P. V. Aylmer.

By J. W. Gregory, D.Sc., F.G.S.

SINCE the famous expedition[1] of the late F. L. and W. James, of E. Lort-Phillips and G. P. V. Aylmer, in 1884–5, opened the Somali plateau to European exploration, the country has been repeatedly traversed. A valuable series of geographical memoirs, hunting journals, and bluebooks has described the main features in the topography of the country, and given many suggestions as to its geological structure. The collections of Dr. Révoil[2] and Prof. Keller[3] have proved that Neocomian beds occur there, and thus have shown that it is of greater interest than most of the monotonous unfossiliferous wastes of East Africa.

In the winter of 1894–5 Messrs. E. Lort-Phillips and G. P. V. Aylmer, two members of the James' expedition, returned to the country, accompanied by Mrs. Lort-Phillips and Miss Edith Cole. Their expedition made some very important botanical and zoological collections, which have been already described.[4] Shortly after their return Mrs. Lort-Phillips kindly entrusted me with the examination of the geological collection which she had made. Subsequently Miss Edith Cole and Mr. Aylmer were also so kind as to lend me their collections. These together enable an outline geological section to be drawn from the coast at Berbera on the main Somali plateau; while, moreover, by the proof of the occurrence of marine Jurassic rocks in this country, they make an important addition to our knowledge of the geological history of Somali-land.

The specimens all came either from the district of Guban, the tract of country between Berbera and the foot of the inland plateau,

[1] F. L. James, "The Unknown Horn of Africa," 1888.

[2] Described by T. de Rochebrune in Geo. Révoil, "Faune et flore des pays Çomalis," p. 39, pls. i–iv. Paris, 1882.

[3] Described by C. Mayer-Eymar. "Ueber Neocomian: Versteinerungen aus dem Somali-land": Vierteljahrschrift Naturfors. Gesells. Zürich, Jahrg. xxxviii, 1893, pp. 249–65, pls. i, ii.

[4] "Diagnoses Africanæ," pt. vii: Bull. Misc. Inform. Kew, No. 105, 1895, pp. 211–30. E. Lort-Phillips, *ibid.*, 1895, pp. 211–30.

or from the Golis Range, on the northern edge of the plateau. The general physical geology of the country has been well described by Captain Swayne.[1]

II. List of the Collections.

Mrs. Lort-Phillips' collection consists of a series of rocks and fossils, of which the following is the list :—

Fossils.[2]	Locality.
Belemnites subhastatus, Zieten	Bihin, in river-bed, 15 miles from Berbera.
Parallelodon Egertonianus, Stoliczka	Do.
Rhynchonella Edwardsi, Chapuis and Dewalque ...	Do.
Rhynchonella subtetrahedra, Davidson	Do.
Coral (gen. et sp. indet.)	Fara-Daro.
Cryptocœnia Lort-Phillipsiæ, n.sp....	Duba.
Rocks.	
1. Sedimentary.	
Compact, hard, light-grey limestone	Duba, eight miles from Berbera.
Quartzose, coarse-grained, red hæmatite, passing into a loose, coarse grit, stained by hæmatite.	Loc. ? No doubt from summit of plateau.
Purple, roughly-bedded, quartzose grit	Daar-Ass, Golis Range. Alt. 5000 ft.
Hard nodules of brown hæmatite; sometimes show crystalline form; they generally show structure, and are apparently concretionary in origin ...	From summit of plateau; weathered out of sands.
Chert; sometimes chalcedonic, sometimes transparent, and at others opaque, milky-white ...	Summit of plateau.
Jasper concretions	Do.
2. Igneous.	
Coarse, quartzo-orthoclase pegmatite	Golis Range.
Thin-bedded, very quartzose muscovite-biotite gneiss	Do.
Pebbles of hornblendic gneiss, with numerous veins and crystals of epidote.[3]	

Miss Edith Cole's collection contains similar rocks, including pegmatite, chalcedonic chert, hæmatite nodules, calcareous tufa, wind-polished limestone from Bihin, and some fragments of roughly-chipped chert flakes.

Mr. Aylmer's specimens contain much the same, with several interesting additions. There is a large specimen of very coarse pegmatite from the face of the Golis, which contains large flesh-coloured crystals of orthoclase, broad tabular crystals of muscovite, aggregates of red garnets, and some long acicular crystals of apatite.

[1] H. G. C. Swayne, "Seventeen Trips through Somali-land," 1895, pp. 361–7.

[2] The Belemnite, the Lamellibranch, and the two Brachiopods have been determined respectively by Messrs. G. C. Crick, R. B. Newton, and F. A. Bather. Notes by Mr. Newton and Mr. Crick are published herewith, and a selection of the specimens has been presented by Mrs. Lort-Phillips to the Geological Department of the British Museum (Natural History).

[3] To determine the character of the mineral in this rock, as it throws light on the nature of some rocks collected by Dr. Donaldson Smith much further to the south, Mr. L. J. Spencer has kindly measured one of the crystals, and has determined them as epidote.

He has also brought back some large mica crystals, which are sufficiently large and clear to suggest that a supply may be obtained of economic value.

His last addition to the series is a lump of an intensely altered hornblendic gneiss from the summit of Wein Deimoleh (or Deymole). This is of interest as proving that outcrops of the Archean series occur in the Maritime Mountains.

III. Description of a new species of coral.

Cryptocœnia Lort-Phillipsii, n.sp.

Diagnosis.—*Corallum* massive, hemispherical.

Calices circular, deep.

Septa hexameral; of two orders. The primary septa are thin, and in length are equal to a third the width of the calix. Secondary little more than rudimentary.

Costæ conspicuous. The confluence of the costæ of different calices is well marked.

Intercalicinal areas very narrow.

Dimensions.—Diameter of calices, 2 mm.; distance of calicinal centres, 3 mm.; number of septa, 6 large and 6 rudimentary; length of primary septa, $\frac{2}{3}$ mm.; height of corallum, 45 mm.; diameter of corallum, 55 mm.

Distribution.—Limestone of Maritime Mountains at Duba, 8 miles south of Berbera, Somali-land.—Presented to the Geological Department by Mrs. E. Lort-Phillips.

Affinities.—This species belongs to the group of *Cryptocœniæ*, in which the septa are hexameral. Of known species it is most allied to *Cryptocœnia Neocomiensis* (E. de F.).[1] From this, however, it clearly differs by having only two orders of septa, and by having thinner intercalicinal areas. Of Jurassic *Hexacryptocœniæ*, it is nearest to *Cryptocœnia Thiessingi*, Koby,[2] from the Swiss Sequanian; but from this it differs owing to the greater amount of cœnenchyma and greater size of the secondary septa in the Swiss species.

There is some doubt as to the age of the Duba limestone. From stratigraphical considerations one would be inclined to regard it as part of the same series as the limestones at Bihin. But it may be Neocomian. The single fossil found does not afford ground for an opinion, though it resembles the Lower Cretaceous and Upper Jurassic *Cryptocœniæ* rather than the Bathonian species.

It is to be hoped that the next traveller along the road to the Sheikh Pass will endeavour to collect more fossils from the Duba limestone.

IV. Section across the Guban and the Golis.

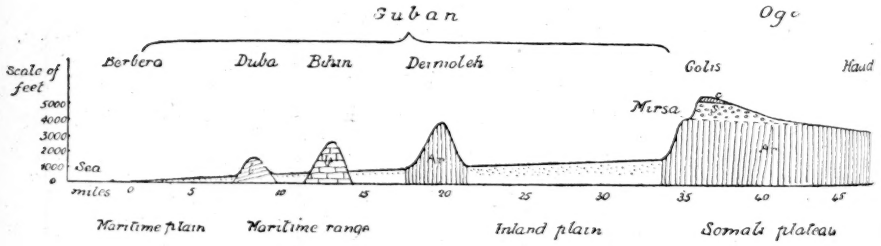
After having thus enumerated the specimens contained in the collection, we may proceed to consider what light they show on

[1] *Cyathophora Neocomiensis*, E. de Fromentel, "Description des polypiers fossiles de l'Etage néocomien," p. 41, pl. v, figs 11, 12. Paris, 1857.

[2] F. Koby, "Monographie des Polypiers Jurassiques de la Suisse," pt. 2, p. 86, pl. xxix, fig. 2: Mém. Soc. pal. Suisse, vol. viii, 1882 (1881).

the general geological structure of the country. The accompanying section shows the topographical features, according to Capt. Swayne's map and some notes given me by Mr. Aylmer.

South of Berbera there is a low plain composed of recent marine deposits, mostly covered by blown sand and soil. Eight miles inland is the first of a series of east and west ridges which form the "Maritime Mountains." These extend for about twelve miles. Then follows the "Inland Plain," which is a continuation of the coast plain: it ends abruptly at the height of 1800 feet, at the foot of the north scarp of the Somali plateau. A steep track leads up the face of this scarp to the Sheikh Pass, at the height of 4000 feet, which leads on to the plateau. East and west of the pass the north edge of the plateau is much higher, rising at one point to 6819 feet. As a rule this northern edge is from 5000–5500 feet in height, while a terrace a mile or two in breadth, known as Mirsa, runs along its northern face at the height of about 4000 feet. The northern edge of the plateau is jagged, and, seen from the north, looks like a mountain range, and is therefore known as the Golis Range. The whole of the low country to the north, consisting of the Maritime Plain, Maritime Mountains, and Inland Plain, is known to the Somalis as the "Guban." To the south of the Golis the plateau descends gradually across the Haud to the valley of the Webi Shebeyli. These topographical features may easily be explained by the collections described.



Alluvium. Limestone of Duba. Bathonian Limestone, [Bihin.

Cherts and Limestones of the Golis.

Red and Purple Sandstones. Archean Rocks.

(The dotted line from Mirsa to the Haud is the level of the Sheikh Pass.)

SECTION ACROSS NORTHERN SOMALI-LAND.

The Maritime and Inland Plains are both occupied by alluvium, marine and subaerial. Through these rise three ridges. The first two are formed of limestone. That at Bihin is unquestionably Lower Oolitic, and no doubt Bathonian. That at Duba may be a part of the same limestone, or a later one, possibly Neocomian in age.

The highest and furthest inland of the three ridges consists of Archean gneisses, and is an outlier from the main Somali plateau.

Whether it has been separated by denudation or earth-movements, there is not at present sufficient evidence to show.

The Somali plateau itself consists in the main of a mass of gneiss and rocks of the Archean series. As usual, this gives rise to the sandy scrub-covered plains, with many mimosa and Sanseviera. The Archean series is penetrated by pegmatite dykes of the same type, but coarser in grain than those of British East Africa. It is capped by rocks of two series—(1) red and purple unfossiliferous sandstones, often passing into impure hæmatite; (2) some limestones associated with beds of chert, probably of Neocomian age. These form the cap of the plateau and the summits of the Golis Range. The ledge of Mirsa and the summit of the Sheikh Pass are both on the upper surface of the Archean series (4000 feet).

The Somali-land sequence therefore consists of the following:—

1. Marine and subaerial recent deposits.
2. Neocomian limestones and cherts.
3. Duba limestone of uncertain age.
4. Bathonian limestones of Bihin.
5. Red and purple sandstones—unfossiliferous.
6. Archean series. (Gneisses penetrated by pegmatite dykes, etc.)

V. The Origin of the Somali-land Fauna and Flora.

The discovery of the Bathonian fossils is of great interest. Bathonian rocks are known in Abyssinia from the work of Blanford,[1] Ferret and Galinier,[2] Aubry and Douvillé.[3] They are also well known from the west coast of India in Cutch. They occur in Northern Somali-land, exactly on the line joining these two localities. Mrs. Lort-Phillips' fossils are especially of value, as Rochebrune,[4] on the basis of Révoil's collections from Somali-land, has disputed the accuracy of the determination of the Jurassic age of the Abyssinian limestones. The presence of Bathonian fossils in Somali-land, however, shows that, apart from the Abyssinian limestones, there are fossiliferous marine deposits of both Lower Jurassic and Neocomian age in this region of East Africa.

The occurrence of one species (*Parallelodon Egertonianus*, Stoliczka) in Somali-land and in India helps to strengthen the idea of the former connection of the Bathonian rocks of India and Somali-land, which is suggested by the apparent extension of these rocks along an east and west line, from Cutch to Shoa. This is of interest, as it throws light on the origin of the interesting fauna and flora of the Golis Range. The report on the collection of plants made in the Golis Range, published in the Kew Bulletin of Miscellaneous Information (No. 105, September 1895, pp. 211–30), shows that the flora of this district contains a very

[1] W. T. Blanford, "Observations on the Geology and Zoology of Abyssinia," 1870, pp. 176–80, 199–203, pl. viii.

[2] Ferret and Galinier, "Description géologique du Tigré et du Samen Voyage en Abyssinie," t. iii, 1847, pp. 54–6.

[3] H. Douvillé, "Examen des fossiles rapportés du Choa par M. Aubry": Bull. Soc. géol. France, sér. 3, t. xiv, 1886, pp. 223–41, pl. xii.

[4] Rochebrune, in Révoil, *op. cit.*, p. 26.

high proportion of endemic species (69 species out of 350 were new). This appears to be due to two reasons. In the first case, the Golis hills appear to contain limestones, which support a more varied flora than the soil formed by the weathering of the gneiss and schist. As travellers generally cross from the lowlands to the plateau by the Sheikh Pass, which has been cut down to the Archean series, they had previously missed this interesting flora.

In the second place, the high proportion of endemic species and the fauna and flora of these hills may be explained by their being inhabited by a group of species which entered the country from land which formerly extended to the east. In the discussion at the Geographical Society on Dr. Donaldson Smith's paper on his journey to Lake Rudolf, Dr. Bowdler Sharpe remarked that some of the Somali-land birds were allied to those of the Cape, and were unlike the representative species that live in the intervening parts of East Africa. It is most probable that the Jurassic rocks of Somali-land are part of a band which once extended eastward into the Indian Ocean, and may have been part of the hypothetical continent of Gondwana-land or Lemuria. This continent was probably separated from Equatorial East Africa, but was connected with the Cape. Thus it is quite possible that some species may have reached both the Cape and Somali-land without entering Equatorial Africa. Hence one of the constituents of the fauna and flora of Somali-land may be a remnant from those of the lost continent of Gondwana-land and Lemuria.

VI. Points for Further Inquiry.

Considering how many travellers are now visiting Somali-land, it may be advisable to refer to some of the principal points in reference to the geology of Somali-land on which material is especially desired.

1st. Collection of fossils from Duba; from any cherts or limestone on the Golis Range; and from Fara-Daro.

2nd. Information as to the dip of the limestones at Duba, Bihin, or Fara-Daro.

3rd. A sketch-map. on the scale of one or two inches to the mile, of any part of the Golis Range which includes the ends of river-valleys running northward to the coast and southward to the Haud. The information especially desired is the course of the valleys, and their relations to the watershed.

4th. A comparison of the succession of rocks seen in the ascent of Wein Deimoleh with those seen in the ascent of the plateau scarp at the nearest point.

II.—On the Occurrence of an Indian Jurassic Shell, *Parallelodon Egertonianus*, in Somali-land, Eastern Africa.

By R. Bullen Newton, F.G.S.

MRS. E. LORT-PHILLIPS, during her journey in Africa, collected some well-preserved *Arca*-like shells from a river-bed at Bihin, in Somali-land, which have been entrusted to me

for determination. The specimens, belonging to one species, are of various sizes, quite black in colour, and covered in places with a lightish-brown matrix.

Externally they resemble *Byssoarca*, having very anterior, distant, and incurved umbones, with a wide ligamental area between, through the centre of which runs a long and straight hinge-line. An examination of the internal characters of the hinge-plate, obtained through sectioning one of the specimens (the valves of all the examples being united), reveals the presence in the left valve of seven or eight small, parallel, and oblique teeth at the anterior end of the hinge; and succeeding these are two long rib-like teeth, arranged parallel with the hinge-line and extending to its posterior termination.

The exposure of this dentition has enabled me to refer the shells to the genus *Parallelodon* of Meek and Worthen, a name substituted by those authors for the better known *Macrodon* of Lycett, which had, unfortunately, been previously used by Müller for a fish. When Lycett first diagnosed this genus it was only known from the Inferior Oolite of the Cheltenham neighbourhood, his type being called *Macrodon rugosus*. Since this, however, it has been discovered in much older rocks, and we now find it recorded as ranging from Devonian times to the present day, recent examples having been described from the seas of the Antilles[1] and Japan.[2] As the Secondary shells of Africa frequently present a strong Indian facies, a comparison had to be instituted before the Somali species could be definitely named or its horizon determined.

Among the Northern Himalayan fossils in the British Museum, two shells were detected corresponding in every detail with those from East Africa, and clearly referable to Stoliczka's *Macrodon Egertonianus*. This species was first figured by Everest in 1833, as an *Arca*; subsequently Blanford mistook it for the Cutch form of *Cucullæa virgata*, J. de C. Sowerby; and still later it was recognized as entirely new by Stoliczka, when it received the name of *Macrodon Egertonianus*.

The Niti rocks and Spiti shales of the Northern Himalayas, which have both yielded this species, besides such well-known forms as *Trigonia costata*, *Rhynchonella varians*, *Camptonectes lens*, *Stephanoceras Braikenridgei*, *Parkinsonia Parkinsoni*, etc., are regarded as of Lower Oolite or "Dogger" age; we may therefore safely assign the African representative of this species to the same position in the Jurassic series.

Genus Parallelodon, Meek and Worthen.

Proceedings Chicago Academy, 1866, vol. i, p. 17.

Macrodon, Lycett [*non* Müller, 1842], Murchison's "Geology of Cheltenham," 1845, pl. v, fig. 5, pp. 98, 99.

Type—*Macrodon rugosus*, Lycett.

[1] *Macrodon asperula*, Dall, Bull. Mus. Comp. Zool. Harvard, 1881, p. 120; *ibid.*, 1885, pl. viii, fig. 4, p. 244.

[2] *Macrodon Dalli*, E. A. Smith, "Challenger" Report [Lamellibranchiata], 1885, pl. xvii, fig. 10, p. 269.

PARALLELODON EGERTONIANUS, Stoliczka.

Area, Everest, "Asiatic Researches" (Calcutta), 1833, vol. xviii, pt. 2, p. 114, pl. ii, fig. 27.

Cucullæa virgata, Blanford, Journ. Asiatic Soc. Bengal, 1863, p. 136; and Blanford and Salter, "Palæontology of Niti, Northern Himalaya," 1865, p. 103; *non* J. de C. Sowerby, 1840.

Macrodon Egertonianum, Stoliczka, Mem. Geol. Surv. India, 1865, vol. v, p. 89, pl. viii, fig. 7.

DIAGNOSIS.—*M. testa oblique-elongata, convexa, angusta, costis radiantibus rugosis ornata; costis ad marginem anteriorem paucioribus, ad marginem posteriorem prope obsoletis; striis concentricis inæqualibus, undulatis, interdumque lamellosis.*—Stoliczka.

Shell obliquely elongate, convex, narrow, with radiating costæ; costæ fewer towards the anterior margin and nearly obsolete at posterior end; concentric striæ unequal, undulating, sometimes lamellose.

DIMENSIONS.

Length	...	...	...	...	40 to 65 millimetres.
Height	...	...	...	...	20 to 25 ,,
Breadth	...	...	...	...	25 to 40 ,,

Remarks.—The Somali specimens exhibit the above characters as given by Stoliczka. In addition it may be noted that a difference exists in the ornamentation of the two valves. The right valves of all examples, whether from Africa or India, show a series of intermittent ribs between the prominent radiating costæ, which are entirely absent on the other valve, where the costæ are rather fewer and wider apart. This is referred to because in his observations on the species, Stoliczka merely states that the costæ "have usually no intermittent ribs between them." The extensive ligamental area is beautifully ornamented with numerous closely-set grooves. Lastly, a curious lithological resemblance may be observed between the Indian and African representatives of this species: both series of shells are of a lustrous black colour, relieved in places by a lightish-brown matrix. If the specimens from Niti in the British Museum were mixed with those from Somali-land, it would be somewhat difficult to separate them, so closely do they approximate to each other in almost every detail.

It is interesting to note, in conclusion, that Mrs. E. Lort-Phillips has very kindly presented five of her best specimens of this species to the Geological Department of the British Museum.

III.—NOTE ON SOME FRAGMENTS OF BELEMNITES FROM SOMALI-LAND.

By G. C. CRICK, F.G.S.

ALL the fragments appear to be referable to the same species. There is not a complete specimen among them; some show the alveolar region, but the majority exhibit only the post-alveolar part, and there is not an example with the apex preserved.

Transverse sections of the guard show that the species here represented belongs to the group *Canaliculati*, as defined by Neumayr.[1]

[1] Verhandl. d. k.-k. geolog. Reichsanstalt, 1889, pp. 52–6.

The guard appears to have been not very long, only very slightly hastate, with a moderately elongated apex; ventral surface with a strong, rather broad furrow, extending the whole length of the guard, disappearing only near the apex, a little narrower on the alveolar region; sides of the guard narrowly rounded, with dorso-lateral vascular impressions, well-marked on the alveolar region, very feeble on the rest; dorsal area broadly rounded, rather flat; angle of the phragmocone 20°; alveolar region nearly circular in section, the post-alveolar region depressed; siphuncle on the same side as the deep groove.

The species resembles *Belemnites Tanganensis*, described by Futterer[1] from Tanga, on the east coast of Africa, where it occurs in association with Lower Oxfordian Ammonites. But Futterer's species is more compressed in the alveolar region, and less depressed in the post-alveolar region, than the Somali specimens. In these respects the latter agree better with the specimen figured by J. de C. Sowerby as *Belemnites canaliculatus*, Schlotheim (=*B. Grantanus*, D'Orb.[2]). The alveolus is shown in one of the Somali specimens; its angle (20°) agrees with that given by Waagen for *B. subhastatus*,[3] to which species he refers the *B. Grantanus*, D'Orb.

The Somali specimens in form agree with certain of the figures that Oppel gives of his *B. Gerardi* (Pal. Mittheil., pp. 273, 296, pl. lxxxviii, figs. 1–3, particularly figs. 1 and 2), which species Oppel states to be narrower and more depressed than Zieten's *B. subhastatus*. In the explanation of the figures, Oppel adds "*B. Grandianus*, D'Orb. MS." This possibly referred to the name *B. Grantanus*, which D'Orbigny gave to the specimen figured by Sowerby as *B. canaliculatus*; and, if so, it would seem that Oppel regarded *B. Grantanus*, D'Orb., and his own *B. Gerardi*, as the same species, although he does not place the former name in the synonymy of the latter.

Stoliczka[4] regarded the *B. sulcatus* described by Blanford[5] from the Spiti Shales as identical with *B. canaliculatus*, Schlotheim, and he also considered the specimen described by Sowerby from Cutch as *B. canaliculatus*[6] rightly determined, and further he thought it was probably for this species that Oppel proposed the name *B. Gerardi*. He adopted, however, the name *B. canaliculatus*, Schloth. A comparison of the specimens from Spiti figured by Blanford with the example from Cutch figured by Sowerby, shows that the latter is more depressed than the former.

In a postscript to the "Palæontology of Niti" (p. 106) H. F. Blanford placed Oppel's *B. Gerardi* as a synonym of *B. sulcatus*, and adopted the latter name for the species.

[1] Zeitschr. deutsch. geol. Gesell., xlvi (1894), p. 30, pl. v, figs. 2, 2*a–c*, 3, 3*a–c*.
[2] A. D'Orbigny, "Prod. de Paléont. stratigr.," vol. i, p. 326, 1850.
[3] Zieten, Verst. Württemb. 1832, p. 27, pl. xxi, fig. 2.
[4] Mem. Geol. Surv. India, vol. v, pt. 1, 1865, p. 111.
[5] H. F. Blanford in J. W. Salter and H. F. Blanford, "Palæontology of Niti, in the Northern Himalaya," 1865, p. 76, pl. x, figs. 1–8.
[6] Trans. Geol. Soc. London [2], vol. v, pl. xxiii, fig. 2 and explanation. 1840.

In his "Jurassic Fauna of Kutch" Waagen [1] refers *B. Grantanus* and *B. Gerardi* to distinct species, regarding the former as a synonym of Zieten's *B. subhastatus*.

Among the fossils brought by M. Aubry from Choa, Douvillé found only one Cephalopod—a single fragment of a Belemnite—which appeared to him to belong to the group of *Belemnopsis sulcata*.[2] It seems to have been associated with *Trigonia pullus*—a form which in this country occurs in the Lower Oolite—and may be identical with that occurring in Somali-land.

The Somali specimens are intermediate between the Spiti specimens [3] which were figured by Blanford as *B. sulcatus* and the Cutch specimen [4] figured by J. de C. Sowerby as *B. canaliculatus*, the transverse section of the Somali specimens being somewhat less compressed than the former, and not quite so depressed as the latter; they appear, however, to come rather nearer to the Cutch specimen, and I have therefore placed them with this species, and have adopted Prof. Waagen's identification of the same as *B. subhastatus*, Zieten.

Horizon.—Waagen states that *B. subhastatus* "is not very common in the Kutch Jura, and is apparently restricted to the beds with *Steph. macrocephalum*," [5] and that *B. Gerardi* "is entirely wanting in the true *Macrocephalus* beds, but begins immediately above it, and extends from here through the whole of the upper part of the Charee group—in other words, it is found in Upper Callovian and Lower Oxfordian beds." [6] In Germany *B. subhastatus* characterizes the *macrocephalus* zone.

IV.—The Dislocation and Disintegration of the Chalk in Eastern England and in Denmark.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

I PROPOSE in the following paper to continue and complete the story which I have partially printed in the Géol. Mag., Feb. 1896, p. 58; but first, a few words about the Yorkshire evidence, which I had overlooked.

Mr. J. F. Blake, speaking of the Yorkshire chalk, says it "has been subjected to the action of some force, which has been strong enough to take hold of huge masses and contort them and stand them on end. A remarkable folding in the rocks was noticed many years ago at Scale Nab, on the coast, by Professor Sedgwick—an equally noteworthy instance of similar action has come under my observation on the summit of the crest between Sherburn and Weaverthorpe. On ascending the hill from Sherburn is a large quarry with the chalk perfectly horizontal, and not more than 20 feet above the level of its upper surface are found beds belonging

[1] Pal. Indica, ser. ix, "Jurassic Fauna of Kutch," vol. i, pp. 13, 14, 1873.
[2] Bull. Soc. Géol. France [3], vol. xiv, p. 223.
[3] Now in the Brit. Mus. Coll., Nos. C. 2566–72.
[4] Now in the Museum of the Geological Society of London.
[5] *Op. cit.*, p. 15.
[6] *Op. cit.*, p. 13.

to the next higher portion of the series standing up nearly vertical, having a dip of 70° to the south. . . . The same beds are seen crossing the surface of the road to a length of nearly 70 feet, so that we must have as much as 60 feet thus set on end. . . . . If we continue upwards a little higher we find a still more marked disturbance about the 500 feet level. Not only are the beds tilted up, but they are actually inverted, so that instead of dipping south at a very low angle they are dipping north at about 45°, having been turned through an angle of 135°. The date of this disturbance is also indicated by these chalk beds actually lying upon stratified Quaternary sand, which forms the mound on which they were stopped. These phenomena indicate a powerful force coming from the direction of the north, during a season in which the lower levels were protected from its influence." (Proc. Geol. Assoc., vol. v, pp. 267–8.)

Again, he speaks of a quarry at Weaverthorpe, in which a mass of chalk stands nearly vertical, and dips actually northward into the hill. . . . The quarry has, in fact, been opened in a huge mass which has broken off the rest, and has fallen or been forced over on to its end.

In another passage Mr. Blake remarks that "In some quarries every fragment has its surface covered with parallel lines at different levels, like a broken mass of basalt in miniature, or even like the appearance of a worn massive coral. . . . This peculiarity has been noticed before by Mr. Mortimer, who thought it was actually due to coral growth; that it is not, is of course proved by the total absence of any real animal structure. . . . The slickensided chalk may be found all over Yorkshire, but *it is nowhere so remarkable as near the change of direction of the line of outcrop*—that is, a little north of its highest elevation." (Blake, Proc. Geol. Assoc., vol. v, pp. 265–8. *The italics are ours.*)

These effects seem to me to be all due to one cause, and that a very recent one, namely, the same cause which gave the Yorkshire wolds their present contour, and which could be no other than a powerful subterranean impulse. How is it possible for anyone who has studied the work of ice in its native home to attribute these effects jauntily, as Mr. Blake does, to the action of ice? "Geologists," he says, "will see in this [*i.e.* in the faulting and bending of these solid beds of chalk], doubtless, another form of those glacial forces which have strewed the bottoms of the valleys, and in some instances hollows at high elevations with boulders and clay." What fantastic writing is this? As an alternative in another case, Mr. Blake suggests that these contortions and upheavals of solid chalk beds have been due to the wasting effect of springs. Uniformitarian champions ought surely to fall back on Mrs. Partington's mop. That would be a real instrument of denudation.

The large boulders referred to in my former paper as occurring further south, are also found north of the Humber. Thus, Mr. Jukes-Browne says:—"Large masses of chalk occur in the gravel; one such

mass, with flint-bands nearly vertical, and now half-quarried away, must have measured some eight yards in length; according to the workmen's account, the part left is ten feet wide by eight feet in height. Another mass, eight feet broad, was just being exposed at the time of my visit, June 1883; while near the entrance there was a third, long tabular mass of chalk about 20 feet long, and passing into reassorted white marl; but the greater part having its bedding so little disturbed that it might have been *in situ*." Speaking of this latter, he continues:—"The seam of dark-grey marly clay at the base of the chalk was from two to six inches thick, and exactly like the bands which so frequently occur in the chalk-with-flints. It would seem, therefore, that a mass of chalk, together with the clay-band, had been quarried out of the hill and embedded in the gravel without disturbance of its bedding or destruction of the clay." ("Geol. North Lincolnshire and South Yorkshire," p. 171.) It seems to me that facts like these are only consistent with the cause I urged in my previous paper.

The great earth-movements that raised the chalk wolds of Yorkshire, in doing so necessarily caused transverse fissures at right angles to the anticlinal lines, thus forming the steep-sided transverse dales which mark them. This was well seen and urged by the older geologists, who had studied mechanics and physics, and did not construct their camels out of their imaginations only. The most important of all these transverse valleys is probably that in which the Humber flows, and which, if not a fissure, presents to us the chalk bent down or sunk to a great depth below high-water mark, and the hollow filled up by the chalky clay, etc., showing that it was made at the same time as the great depressions of the chalk marked by the well-borings at Boston, in Lincolnshire, and Yarmouth, in Norfolk.

The steep sides of these buried valleys are remarkable. Thus, Mr. Jukes-Browne says of a gravel-pit west of Wold Newton church: "From this depth of 40 feet the chalk rises steeply on either side in a series of rough slopes" (*op. cit.*, p. 171). Again, Mr. C. Reid says: "Great Limber is partly on gravel and partly on chalk, the gravel having its limit generally well defined by a sharp rise of chalk. . . . . The abrupt rise of the chalk at Limber brickyard is very curious; for one of the cottages belonging to the pit is on chalk, while not 80 yards away, on the same level, there is at least 37 feet of sand and warp" (*id.*, p. 180).

Turning to the valley of the Humber, Mr. C. Reid, in his "Geology of Holderness," tells us that under it "there is evidently a considerable thickness of boulder-clay, though none of the borings yet made have shown the full depth of the old, probably pre-Glacial, Humber valley. . . . . They prove that boulder-clay, interstratified with sand and gravel, *reaches a depth of at least* 83 *feet below the present level of high-water*; and, judging from the dip, there will be a still greater thickness in the old channel." He quotes other cases thus: one boring, 300 yards east of Hessle ferry, reached chalk at 42½ feet below high-water; a second,

immediately within the Humber bank, reached it at 44 feet; another, in 26 feet of water, reached it at 24½ feet; another, in 33 feet of water, at 22 feet; another, in 33 feet of water, at 23 feet. In one case, a boring in 25½ feet of water, chalk was not reached at 58½ feet. In another, where the bore-hole started at 3 feet below high-water, chalk was not reached at 72½ feet. (*Op. cit.*, pp. 39, 151.) In a bore-hole at Reed's Island, in the Humber, chalk was reached at 185 feet.

Mr. Reid speaks of the chalk south of Barton as glaciated (that is, in ordinary language, broken and dislocated) to a depth of several feet; and the irregular depths at which it occurs from the surface show that it must be much crumpled, bent, and warped; and inasmuch as the hollows created by the flexures, which go down considerably below low-water, are filled in by boulder-clay only, it is virtually certain that they occurred either coincidently or just before the clay was distributed.

That these flexures and dislocations were caused by a very different force than any that could be exercised either by glaciers or icebergs, seems evident when we test the problem in the true inductive way, namely, by placing side by side the phenomena in question from Eastern England with those from Dorsetshire, where we have effects largely of the same kind and degree, in an area where ice-sheets and icebergs cannot be postulated. The dislocation about Purbeck and in the Dorsetshire Chalk are good indices that the effects in question were due to subterranean forces, and not to the great ice monster continually invoked by the wilder glacialists.

Let us now turn our glance further east. It is a great pity that so little has been done during the last half-century to illustrate the constitution of the sea-bottom of the German Ocean. We know its contour well enough, but the distribution of the rocks that form its bed we can hardly be said to know, and yet materials are available. At Southwold and other places on the east coast, the so-called "crabs" to which the fishermen fasten their boats, are piled up with subangular masses of rock, including lumps of chalk, of Coralline Crag, as well as of crystalline rocks, which have been trawled, and about whose provénance the fishermen have collected considerable details; and it is a great pity that the Geological Surveyors, who have spent so much time on this coast, have not made more inquiries on the subject, and furnished us with more materials for settling some doubtful questions.

Two things, however, seem perfectly plain: one is, that the folds and bends which mark the chalk in East Anglia, Lincolnshire, and Yorkshire, also mark the beds underlying the German Ocean; and inasmuch as we meet with the chalk again in folds when we reach Denmark, it seems probable that the Cretaceous beds were once continuous right across the North Sea. I am informed by a distinguished hydrographer, that when the Trinity House proposed to erect a lighthouse on the Goodwins a boring was put into the ground, and that chalk was rapidly reached. This shows that the Goodwin Sands form an anticlinal saddle or down. The Admiralty

charts show a chalk bottom off the eastern coast of England, both off Kent and Essex, indicating that this depression is a synclinal hollow in the chalk.

It is equally probable, although of this we have not the same direct evidence, that the Dogger Bank is another chalk down covered with sand, and it is not unlikely that some of the chalk lumps brought in by the Southwold fishermen have been dredged on the Dogger. Between that bank and Denmark there has been some denudation, for when we reach the Danish coast, some of the beds below the chalk are exposed: perhaps this has been an area stripped of its covering of chalk, like the Fen depression and the Weald.

Proceeding still eastward, we come to the chalk of Jutland, and then to the broken and dislocated chalk beds of Moen and the other Danish islands, which present such a remarkable parallel to the dislocated chalk beds of England, and the discussion of which by the foremost German geologists has apparently largely escaped our own writers — the only person known to me who in recent years has referred to them, and he only casually, being Professor James Geikie.

I will give a short conspectus of the most recent views. First, as to Lyell's observations and conclusions. He says:— "The chalk in the cliffs at Moen, which are from 300 to 500 feet high, is in beds partially vertical, partly curved, and has undergone extreme disturbance. As we find a range of the English chalk in Purbeck and the Isle of Wight, where the strata are much dislocated and thrown on their edges, while in the immediate neighbourhood of the line of convulsion strata of similar chalk are traced over a wide area in horizontal or slightly tilted position, so in Denmark we remark the like contrast between the state of the white chalk-with-flints which occurs in the neighbouring islands of Seeland and Moen. . . . The Moen cliffs are subdivided by deep ravines into separate and distinct masses. . . . They are, in fact, narrow clefts, coinciding with lines of fracture and dislocation. . . . The first opening or narrow valley is near a rock called Taleren: a deep ravine here comes down at right angles to the line of coast. . . . Another great line of fracture further south, at Sommerspiret, where another ravine, filled with clay and sand, comes down to the sea. Here, as afterwards, in a third break in the cliffs further south, I observed the strata of chalk dipping on the opposite sides of the ravine towards the hollow. . . . The cliff called Dronningestolen is between 300 and 400 feet high, nearly three-fourths of which are perpendicular, but the lower part is a sloping mass of solid chalk-with-flints, the beds of flint being highly inclined towards the sea. . . . Two rents descend perpendicularly, and terminate, the one at a depth of 100 feet and the other of more than 150 feet, from the top of the cliff. They are filled with sand, and near the termination are two caves, one of which is 14 feet and the other 16 feet high. They may be sections of subterranean passages, and are distinctly connected with dislocations in the chalk." . . . . Lyell suggests, that the upper

portions of some of the chasms may have closed again. . . . . "Their movements," he said, "have produced sharp curves in some places, and in others great faults in the strata of chalk, which are beautifully marked by the lines of black flints. Occasionally a mass of chalk, divided by regular layers of enclosed flints, abuts abruptly against another in which no flints, or scarcely any, are visible. Almost every other imaginable form of dislocation may sometimes be met with. I did not see any flints shattered *in situ*, and I am told they have rarely been observed." Lyell compares the phenomena at Moen with the large masses of chalk in the Norfolk cliffs, and says the appearances are strictly analogous, but in Norfolk are on a much smaller scale. "*In both cases, they compel us to assign a comparatively modern date for an era of partial but violent convulsion, by which the chalk has been deranged.*" (Trans. Geol. Soc., 2nd ser., v, pp. 252–7.)

In the abstract of this paper, which was read before the Geological Society, on May 13th, 1835, Lyell says:—"In consequence of the disturbances the chalk has been made to alternate on a great scale with interposed and unconformable strata of clay and sand. These alternations cannot be explained by supposing the detritus of the superincumbent strata to have been washed by running water into clefts; *but masses of the Tertiary beds seem rather to have been engulfed.*" (Proc. Geol. Soc., ii, 192.) He further adds, that Dr. Forchhammer had discovered similarly disturbed chalk in the Danish island of Seeland.

In his address to the Geological Society in 1836, Lyell again refers to these dislocations, and says:—"The movements have been on so great a scale that masses of the overlying clay and sand have subsided bodily into large fissures and chasms, intersecting the chalk to the depth of several hundred feet. *Some of the intercalations of clay and sand, in the midst of great masses of unconformable chalk, can only, I think, be explained by supposing engulfments of superincumbent matter, such as are described to occur in earthquakes.*" (*Id.*, p. 366.)

Dr. Beck, in a paper communicated to the Geological Society in 1835, speaks of the masses of gravel and sand which in Moen have, in consequence of great disturbances, become entangled with portions of disrupted chalk. In the neighbourhood of Thisted, at Thye, to the north of Mors, and in the island of Führ, *Dr. Beck observed in* 1831, *dislocations which affect equally the Tertiary strata and the Chalk.* He further says that since the sandy beds of Denmark sometimes contain shells identical with those now living in the German Ocean, it is evident that the chalk in Denmark has been submerged since the existence of the living species of testacea. (Proc. Geol. Soc., ii, p. 217, etc.)

The next reference I can find to these dislocated chalk beds is in a memoir by C. Puggaard, entitled "Uebersicht der Geologie du Insel Moen," published at Berne in 1851. Lyell speaks of him as a most able and reliable authority. To be clear, he says:—"The escarpment of Moens Klint is about 18,000 metres in length; along this length

of cliff it is only at each end that the chalk and the superincumbent soft beds lie in a horizontal position. In the intermediate space the strata of chalk are twisted, curved, and bent in all ways, in the form of an **S** or a **Z**, in a semicircle or stirrup-shape, or, again, cut by chasms, forming enormous faults, and interlaced in the most extraordinary fashion. About the middle of the scarp, at a place called Dronningestol, the confusion attains its maximum, and there the cliff rises to its highest point, 420 metres. The dip of the strata also varies greatly and changes continually, in some places passing abruptly from a horizontal position to a vertical one; and, what is most remarkable, the inclination of the strata seems less marked at the summit of the scarp, and the inclination of the beds increases rapidly as we go down, and sometimes the beds are more than vertical, the chalk resting on the diluvian beds, but always in order" (toujours en stratification concordante). He gives several sections showing how in several ravines in the island the layers of clay and sand follow the exact lines of the chalk. In other ravines it is only on one side that we have this continuous superposition; on the other the drift beds are sharply cut off, and often plunge below the chalk, so that the chalk lies on the drift in discordant fashion. The faults are often difficult to find, especially those occurring where the strata are much inclined. By means of these breaks and faults, beds of clay and sand often look as if intercalated in the chalk; but on examining the place closer, it is found that where the chalk looks as if it rested on the clay it is separated from it by a breccia filled with angular pieces of flint and mixed with clay containing rolled pieces of granite.

It is often found that the edges of the inclined strata in the ravines are bent over in a direction opposite to the run of the ravine, showing whence the force has come which made them. The hills in the centre of the island have very steep sides, with pronounced outlines, and are separated by deep ravines, showing that notwithstanding the soft surface mantle, the contour of the country is really due to subterranean forces. The lines of fracture extend to Denmark, and are marked there by fjords, etc. "I am convinced," says Puggaard, "that the surface of Denmark owes its contour much more to the bending and plication of its strata, and to subterranean movements, than could at first sight be supposed from a mere examination of its surface beds." *He further argues that the dislocations in the Isle of Moen referred to, all date from about the same geological epoch*; but from the different directions of the rents, he attributes them to different shocks. In addition to the principal dislocations, there are secondary ones almost at right angles to the former.

Puggaard gives many details about the changes in the dip of the strata in various parts of the island, and many sections to show the actual facts; and he concludes that the dislocations were the result of some very violent lateral pressure, which he attributes to the shrinkage of the earth's crust, and which gave way in certain weak places. From the fact of the lower strata being more affected than the upper, he judges that it was rather the result of collapse

than of elevation, and that the effects so remarkable in Moen were the result of the sinking in of the bed of the surrounding sea to the depth of 500 to 600 feet; this affected the whole island, together with Denmark, which afterwards rose again covered with its mantle of sand and clay and boulders. Then it was that the scarped cliffs of Moen were formed, and became the subject-matter of attack by the waves of the Baltic, reinforced by the waters of the Arctic Ocean, coming by way of the then open Bothnian Channel. He considers that this sinking probably affected the whole of the North and East European districts where the drift phenomena occur, and also extended to the mainland of Denmark and of Scandinavia, and he considers the Swedish Asar and the Danish sand rücken as due to the same cause. The depth to which he carries this sinking is apparently based on the height above the sea-level at which marine shells have occurred in Scandinavia and England. *He attributes the dislocations in the strata of Moen to about the time of the so-called Glacial age, and adds the notable words*—"Ich glaube dieses Ereigniss als eine bequeme Grenze der Tertiären und Quaternären Periode für Nord Europa ansehen zu können obschon eine scharfe Scheidung der beiderseitigen Bildungen nur ausnahmsweise möglich ist." (*Op. cit.* See also Puggaard, "Sur la geologie de l'île de Moen": Bull. Soc. Geol. France, 2nd ser., viii, p. 532, etc.)

Lyell, the great champion of Uniformity and a very keen critic of the work of others, adopts and incorporates the arguments and results of Puggaard in his "Antiquity of Man."

We must now pass on a few years. In his memoir published in 1874 on the dislocations in Moen and Rugen, F. Johnstrup endeavoured to account for them by appealing to ice.

Against this view more than one famous German geologist protested. Von Koenen, in examining the broken and dislocated chalk of the Danish islands, contests the possibility of ice having anything to do with it; he traverses Johnstrup's case in detail, and compares the phenomena discussed by him with the very similar phenomena he has himself described in Hessen and on the Weser, and notably in the districts of Kreiensen, Göttingen, Marburg, Hersfeld, Geisa, and Vacha, where no traces of northern erratics or ice-work occur, and where they cannot, therefore, be attributed to ice. He especially quotes the underpinning of the great chalk masses by boulder-clay and sand, which he compares with the reversed strata at Hüggel, near Osnabruck, where the Middle and Upper Lias are thrust in below the beds of Zechstein. He compares the hollows and basins of various shapes occurring in Rugen with the similar hollows in Central Germany, which he had already shown to be due to the sinking of the ground; he points out that the faults which occur in this district are of Pleistocene age, and argues that the general dislocations were coincident with a sinking of the bed of the Baltic. (See A. von Koenen, "Ueber post-glaciale Dislokationen": Jahrbuch der Königl. Preuss. geologischen Landesanstalt und Bergakademie, 1886, pp. 1–19.)

In 1889, Berendt published a paper in which he reverted to Johnstrup's explanation, and argued at considerable length in his favour. This, again, was answered, with great force and in great detail, in a memorable and, as it seems to me, conclusive memoir by R. Credner, in which he made the position so long ago sustained by Lyell unassailable. The fact is the more remarkable since R. Credner is himself a champion of extreme glacial views. He tells us, that the view held by von Koenen was strongly supported by the geologists who went on an excursion after the Geological Congress at Greisswald in 1889. They noted also that the dislocations in the cliffs north and south of the Kiel Brook, formed a row of parallel ruptures extending from SSE. to NNW., and were accompanied by a series of step-like sinkings of the intervening strata. R. Credner adds, that during his own numerous excursions, and especially in 1890 and 1892, when he spent several weeks on the island of Moen, he was satisfied of the justice of von Koenen's conclusions, that the disruptions were due to the forces which gave the island its contour, and not to ice-action at all. The paper is too long to condense here, and those who still need convincing had better turn to its elaborate descriptions, arguments, and especially to the sections, to see how utterly inadequate ice, in any form we know it, would be to bend these great masses of chalk into reversed folds, into arches and synclinal hollows, and to do so frequently when the chalk was coated, and had its surface therefore padded, with layers of soft materials—sand, clay, etc. Credner's paper has not been answered, or criticized even; and it seems to me not only conclusive in itself, but to be a very eloquent complement to the evidence of the disturbed chalk of Britain presenting the same features and preaching the same lesson.

Let us now revert somewhat. As we have seen, the Geological Surveyors in East Anglia and the German geologists in Denmark attribute the flexures and dislocations of the chalk to the same period, namely, that in which the boulder-clay was distributed. This is confirmed when we turn to the submerged downs of the North Sea, over all of which, over the Dogger Bank, the Goodwin Sands, the Haslow Oyster Bank, the Knole Sand, etc., numerous remains of mammoths and their contemporaries have occurred. This, it seems to me, can only be explained by the submergence of the North Sea being subsequent to the formation of the land-surface on which the mammoths lived. If, as some have held, these remains found under the North Sea were carried down by the Rhine (another of the postulates of Uniformity which outrage common-sense), it is extraordinary that they should occur so unweathered and unrubbed, not in the hollows where the river may have flowed—if it then existed, which is very doubtful—but along the ridges. The widely-spread area of the North Sea where the unrolled remains occur, and the fact that they are so often found on the submerged ridges and downs, make it plain that we have to do here with a wide area which has been recently submerged.

The fact of these bones and teeth being so fresh and unweathered,

shows us further that the submergence was not gradual, the result of continuous cutting back of a sea-coast by diurnal causes, but a widespread and cataclysmic one, or these bones would not be found in some cases articulated, and in all cases with their finest muscular attachments intact, but would be rubbed and converted into a kind of bony shingle.

In this behalf I should like to quote an opinion of Murchison, now perhaps forgotten. Referring to the existence of mammoth bones in a submarine forest off the Norfolk coast, he said that this commixture had been pointed to as indicating long and slow action. He viewed it as evidence of sudden movement. "When examining a similar submarine forest," he says, "with the trunks of trees still erect, the late eminent Dr. Forchhammer, of Copenhagen, came to the conclusion, as he informed me, that the movement by which they were submerged must have been sudden. He argued that the rapid immersion of the trunks, and their having been quickly surrounded by marine mud, could alone have preserved them; for if the trees had been gradually sinking at the rate of an inch or two in a year, they would have been entirely decomposed under the atmosphere long before their submergence." ("Siluria," ed. 5, p. 491.)

These conclusions are further confirmed by another, for which I have fought very hard in these pages, namely, that the chalky clay of Eastern England is shown, by every case where the evidence is clear, to overlie the land-surface on which the mammoth lived. Mr. Horace Woodward has quoted some cases bringing into close chronological sequence the destruction of the mammoth and the disintegration of the Chalk of Eastern England. Thus he quotes the discovery, about the middle of the last century, of "part of the horn and palm of a deer, found in a chalk-pit at a village called Baber, four miles east [west] of Norwich, at the depth of 16 feet, and almost converted into a chalky substance." S. Woodward confirmed the discovery by Arderon of deer's horns in the disturbed chalk at Whitlingham and Sprowston. Arderon describes a man's skeleton as having occurred in the same bed. Since this time, says Mr. Horace Woodward, Mr. J. W. Ewing, Mr. Fitch, and Mr. Bayfield have brought many specimens, including shed antlers, under the notice of the Norwich Geological Society. These include the mammoth, the red deer, and another species, like the roe deer; while the localities of Thorpe, near Norwich, Hartford Bridge, Markshall, and Eaton, have been added to the list.

E. primigenius has been found in the cutting below the viaduct near Hartford Bridge, and in chalk rubble, Norwich; while antlers of deer have been found at Norwich, Trowse or Lakenham, Markshall, Eaton, and Whitlingham. On March 4, 1868, Mr. J. W. Ewing exhibited before the Norwich Geological Society several portions of antlers found in the rubble or disturbed chalk in his grounds at Eaton. Mr. Gunn says he was struck with the marks of cutting and abrasion, by some blunt instrument, of the pedicle of one specimen of the red deer, and of sawing on another. A stone

implement was said to have been found with the bones of deer. (H. B. Woodward, "Geology of the Country round Norwich," pp. 137 and 138.)

I will now endeavour to sum up in a few phrases the main conclusions which seem established by the evidence.

1. Before the distribution of the Drift, the Chalk extending from Norfolk, Lincolnshire, and Yorkshire, to Scania, in Sweden, was, so far as we can judge, a perfectly continuous deposit, neither bent into folds nor marked by conspicuous alternations of valley and down.

2. This great stretch of more or less level chalk was overlain, either completely or partially, by beds of Eocene age, consisting of variegated clays and of smoothed and rounded flint pebbles, of which considerable remains still exist under the Drift in East Anglia; while the débris of those which have been denuded and broken up now form the shingle beds and various gravels of Eastern England, there not being in that area, so far as we know, any pebble gravels *whose constituent* pebbles do not date back to Tertiary times.

3. Over these Eocene beds were placed the Crags. How far the Crag beds extended over the bed of the North Sea, we do not know; but among the lumps dredged by the Southwold fishermen are several of the White, or so-called Coralline Crag; while, as is well known, in more than one place in the North Sea area, dead shells of later Crag age have been dredged.

4. Over these Crag beds, again, was a land-surface, on which the mammoth and its companions roamed, and which extended from Denmark to Yorkshire. We have no evidence to show that the Rhine flowed through this now submerged land. It may be, on the contrary, that its drainage was entirely reversed and that it then flowed southwards.

5. The beds above named, from the Chalk or perhaps the Oolites upwards, were presently affected by a great movement, of which other examples occur in geological history, by which they were bent and moulded into a succession of wolds and intervening valleys. This movement led to their very considerable dislocation and disintegration, and to the denudation of large areas, such as that occupied by the Fenlands; and it was by this movement that the present contour of Eastern England, of the bed of the North Sea, and of Denmark, were shaped.

6. The products of this disintegration, in the shape of chalk-rubble, were subsequently moulded and mixed into what we know as the Chalky Clay, which was afterwards distributed in its present form. How this came about, I may be able to show on another occasion. This view, which I reached independently, is very largely the same conclusion arrived at by the father of the Woodwards, who in his "Geology of Norfolk," published in 1833, says that "the elevations in the neighbourhood of Cromer originated in the disruption of the Chalk strata, and are most probably of the same age as the valleys. The natural section of the cliffs shows, in the disrupted chalk, the origin of the Beacon hill at Trimingham; and to the westward of Cromer is seen a large mass of chalk

at the upper part of the cliff in a perpendicular position. These are beyond a doubt effects of the same cause. On the lighthouse hill at Cromer also, the chalk is forced up to the surface, 200 feet above its natural level, and a limekiln is worked on the spot. The valleys of Norfolk are such as are denominated '*valleys of elevation*'; that is, they were formed by the upheaving of the chalk and its consequent fracture. This is demonstrated by the agreement of the 'salient' with the 're-entering angles' of their borders, and from the fact of the layers of flint in the chalk, on each side of the valley, being found to decline from its line of fracture." In describing the general results of his inquiries, S. Woodward, *inter alia*, urges that the chalk was disrupted subsequently to the period when the great mammals lived in Norfolk, when, he argues, this country was separated from the continent, at the same time forming the valleys of Eastern Norfolk and the drainage of the county. (*Op. cit.*, pp. 6–9.)

V.—Clays, Shales, and Slates.

By W. Maynard Hutchings, F.G.S.

In pursuance of my studies of clays, shales, and slates, I have recently been examining some specimens to which a good deal of interest attaches. Some of them are Carboniferous shales from deep collieries in South Wales. Another, also a Carboniferous shale, is from a deep boring in the Isle of Man.

The object in view, in examining these specimens, was, in the first place, to see how far they agree in general nature and chemical composition with the very numerous Carboniferous clays and shales which I have investigated from other districts. In the second place, it was desired to see whether these shales from considerable depths had made any perceptibly greater advance towards becoming slates, than those derived from points very much nearer the surface; whether they were harder and more compact; and whether they showed a corresponding change in the nature of their minerals, or of the arrangement of these in the *structure* of the rock.

As regards the chemical composition, I have made the following analyses. *A* is the deepest of the Welsh shales, from 1300 feet. *B* is the specimen from the Isle of Man, but I do not know the exact depth from which it was taken.

A.		B.	
Silica	66·10 per cent.	Silica	58·75 per cent.
Alumina	20·55 ,,	Alumina	19·15 ,,
Ferric oxide ...	1·67 ,,	Ferric oxide ...	3·90 ,,
Lime	1·40 ,,	Lime	1·15 ,,
Magnesia	0·84 ,,	Magnesia	1·95 ,,
Potash	2·85 ,,	Potash	3·48 ,,
Soda	0·78 ,,	Soda	1·54 ,,
Water and organic matter	6·55 ,,	Carbon dioxide ...	1·36 ,,
		Water and organic matter	8·87 ,,
	100·74 ,,		100·15 ,,

The analysis *A* shows an unusually low amount of iron, but with this exception the composition corresponds pretty closely with similar rather quartzy shales from other coalfields, as, for instance, with No. 1 of a series of six analyses which I published (Geol. Mag., January, 1894, pp. 36 and 64) of fireclays from a borehole at Aspatria, near Carlisle. Notably, the relative proportions of potash and soda, the great excess of the former, are here maintained.

The analysis *B* shows in general a similar composition, but this shale contains a noticeable amount of grains of a carbonate (probably of lime, magnesia, and iron) more than I have seen in any other Coal-measure clay or shale. Also, the excess of potash over soda is less than is usual in these deposits. I am not aware from what exact position in the Carboniferous beds the specimen was taken.

The Welsh shale is a decidedly quartzy and coarse-grained specimen, as compared with the finest-grained, hard fireclays from the borehole at Aspatria and elsewhere. It still shows a considerable amount of clastic muscovite in good-sized flakes, and here and there even a bit of not yet wholly decayed biotite may be seen. These Welsh specimens are very deeply coloured with organic pigment, which makes sections of them very opaque and bad to examine, in comparison with the much less pigmented grey shales and clays from some other sources; but the general nature is still easily made out, being the same as in the other cases. There are the rutile-needles, small anatase crystals, and other minerals as usual, and the finest-grained "base" of newly-formed micaceous material.

The same remarks apply in all principal respects to the Isle of Man shale, though it is not so quartzy as the Welsh specimens, and contains, as before stated, some carbonates disseminated through it.

So far as concerns the physical condition, and development towards slates, these specimens differ only from those previously examined inasmuch as they are considerably *less* advanced than many which have come from very much smaller depths. They are, in fact, just very hard clays; they can easily be cut with a knife, and when ground with water they are quite plastic. They have, in fact, not made any advance at all beyond that of the considerable *chemical* changes and the very moderate *physical* progress which is common to all the clays and shales of the normal Carboniferous beds; and it does not appear that we can look for any gradually higher stages, among these deposits, to assist us to bridge over the interval between soft shales and well-developed slates, or to understand what it is which takes place in them during the passage through the intermediate stages.

Such fully-developed slates we can only study, in this country at least, among the older formations, with the exception, possibly, of certain local occurrences in the Culm of North Cornwall, etc. In other regions highly-developed slates are found among rocks younger than the Carboniferous. It is not, by any means, simply a question of geological age.

In considering these higher phases of "slates," as contrasted with soft shales and indurated clays, it is not so much the mechanical

question of cleavage, etc., which is of interest, as the mineralogical nature and inner structure.

In the rocks we call "slates" we are accustomed to see a more or less high degree of cleavage, and, indeed, to commonly more or less associate this development of fissility with the very name. But with this cleavage we usually find that other changes have been brought about, which are petrologically of far greater interest and importance, —great alterations in the component minerals and in their arrangement in the rock.

We know that the development of cleavage is a purely mechanical affair, which may be brought about in any fine-grained rock, sedimentary or otherwise, by pressure. In dealing petrologically with "slates," we are not tied to this quality of cleavage. We can have bodies of sedimentary rock around igneous masses, which have had their former cleavage obliterated by the effects of the intrusion of these masses, but which we must still call slates. And we may have beds of soft shales, converted by such igneous masses direct into contact-rocks without any cleavage at all; which are mineralogically and structurally slates, and to which we could not at present conveniently apply any other name.

It is just these mineralogical and structural developments of the deposits, which accompany the change into slates, which are of so much interest for us to endeavour to follow out; to find, if possible, the different causes to which we must attribute the variations in these developments, both in kind and in degree, which become apparent to us when we study sufficient examples of slates, or going further forward, of phyllites and schists.

It may be as well to take a general review of the subject of the origin and development of the deposits from which our normal sedimentary slates, and allied rocks, may be traced; and to take stock of such facts concerning this development as seem, on microscopical, chemical, and general evidence, to be either fairly demonstrated or rendered highly probable.

In the first place, then, all the evidence we can gather appears to justify the belief that the great bulk of these slates is derived from the sediments consisting of the waste of vastly older granitic and gneissic rocks, and that in the indurated clays and soft shales of the Carboniferous beds we have a series of closely similar deposits, of like origin, preserved for us in a relatively early stage of their history. Any observations, therefore, which we can make on these Carboniferous deposits, will assist us to a general understanding of the progress of all such sediments into slates, and of the alterations which these, again, may undergo at later stages of their existence.

If we take for our study mainly the finer-grained parts of these deposits, we shall best arrive at the desired conclusions; because any increase in coarseness of grain simply leads on to the more quartzy slates and grits, and finally to the argillaceous sandstones; in all of which rocks the original nature and subsequent changes of the finer argillaceous portion of the materials are the main points to be considered.

It has been shown that *chemically* such clays and shales are very exact counterparts of quite typical clay-slates and phyllites. If we compare the average analysis of a series of the one, with that of a series of the other, we cannot point out any marked, or in any way essential, difference whatever, excepting that the combined water in the slates is less than in the clays and shales.

Again, a minute examination of these clays and shales under the microscope, in thin sections and in the products of fractional levigation, has led to the conclusion that mineralogically, also, there is a great resemblance to the slates, inasmuch as they consist mainly of a micaceous mineral. And a careful study of this micaceous mineral, combined with the fact that in these finer portions of such deposits there is a disappearance of all the felspar, practically all the biotite, and a large part of the original clastic white mica (all of which can be proved to be in abundance in the accompanying coarser beds), leads to the recognition of the nature of this micaceous mineral as a new formation in the clays and shales, since they were deposited.

In comparing such clays and shales with most slates and phyllites there is, however, one difference to note, and it is a matter of much importance in following out the history of such beds. It consists in the fact that whereas in the slates and phyllites the micaceous mineral is accompanied by a good deal of a chloritic substance, with which it is more or less intimately interwoven, we do not see this in the clays and shales.

It was pointed out in an earlier paper (GEOL. MAG., June and July, 1890) that chlorite does not result from the decomposition of brown mica in these deposits. A certain small amount of it may be seen in them, especially in the rather coarser portions, but it is easily recognized as clastic, and is doubtless due to the decay of biotite in the original rocks whose waste has supplied the material for these beds. In the processes of chemical interaction which have taken place in these early clays and shales, chlorite has not been formed; and we are justified by all that we can ascertain, chemically and microscopically, in concluding that the micaceous mineral which does result contains within it those components—magnesia, ferrous and ferric oxides, alumina—which would be capable of combining with silica on their own account to yield a chlorite. We have, in fact, in these clays and shales a micaceous mineral which is very complex in its nature, is highly hydrated, and does not correspond to any definite species of mica. It is of a pale-green, or yellow-green to yellow colour, and does not polarize quite as vividly as do minute flakes of muscovite.

In the beds of the Coal-measures in undisturbed bands (not connected directly with coal-seams), suitable sections of clays and shales show that the micaceous mineral is very nearly all flat in one plane; but in some of the more indurated, and what might be called more *advanced*, samples examined this is not so completely the case. The great bulk of it is still flat in one plane, in which it gives, in polarized light, a dim speckled field; but this field is crossed by

little veins and strings and wider bands, highly inclined or even vertical to this plane, of a minutely-felted and wavy mass of flakes of the same or a similar mineral, but obviously in a more developed stage. There is no mistaking that these veins and bands have been formed later than the main mass seen in the section, and that they represent a further development and crystallization of a micaceous mineral which is still in general nature and appearance the same as the main mass, though with crossed nicols it shows more vivid tints; and the peculiar felted and wavy structure of the little veins is very noticeable.

If we now pass at once to the consideration of what we may call fully-developed slates of Silurian or Cambrian age, limiting ourselves for the present to occurrences concerning which there is no evidence that they have ever been affected by igneous intrusions; and if we compare these rocks with the clays and shales we have just left, we find, as before pointed out, only one chemical difference, viz. the decrease in the amount of combined water. But careful mineralogical study of the slates with the microscope results in our being able to note two main points of variation between them and the clays and shales. The degree of these differences varies very much, as the exact condition of the slates varies in different occurrences, but in nearly all cases we can see the points in question. There is a higher development of the micaceous mineral, and concurrently there is the separation in the rock of a chloritic substance, to which reference was made above.

By higher development of the micaceous mineral is meant, not only a development in size, for this is sometimes not at all striking, but an advance towards the nature of *muscovite*, often with a noticeable clarification as to colour, and increase in the vividness of polarization-tints.

The chloritic mineral which has been formed at the same time is very intimately interwoven into the texture of the rock. Often it is mainly in minute mixture with the mica, flake for flake as it were, but usually this form of occurrence is accompanied by the formation of streaks and lenticles of chlorite, in which mica is seen to a much less extent, or from which it is even absent.

It seems quite evident that what has taken place in the rock during its progress from a clay or shale, has consisted mainly in this further development and crystallization of the micaceous mineral, during which it has rejected some of the components of the original more complex combination, which components have then given rise to the formation of the new chloritic mineral.

This chloritic mineral varies in its nature and appearance according to the chemical composition of the rock in question, the principal condition being, apparently, the amount of iron present, and more especially that portion of it which is in the form of ferrous oxide. Thus, sometimes the mineral is dark green and very dichroic, with decided "polarization"—is, in fact, *chlorite*, and can be proved to be such,—while in other cases it is very pale in colour and optically very faint; and in some few rocks it is, in the thin sections used,

quite colourless and optically inert. For convenience we will speak of it in all cases as "chloritic," without attempting to specify its exact nature and composition.

It is often difficult to make out how much of this substance is present, even when it is of a decided green colour, because of its very intimate intermixture and the smallness of some of its flakes; and when it is verging on colourless it is even difficult to detect it at all in ordinary sections. But for the study of this class of rock it is of very great use to take specimens, of suitable size for cutting sections, and heat them to dull redness for some time. This dehydrates the chloritic mineral, and when it is of green colour leaves it with more or less deep shades of brown or of red, in which condition it can be easily detected, even in a most minute and intimate state of subdivision. And even when it is nearly or quite colourless, it is thus rendered more opaque, becomes tinted, and can be seen where it was previously invisible. Sections made from these dehydrated specimens are, therefore, of the greatest value when used in conjunction with those of the normal rock.[1]

They show, too, another useful and interesting point. The more impure and less developed mica is also affected by dehydration and by the oxidation of the iron it contains, taking on colours which range from yellow to various shades of brown, and even to good strong red, according to the degree and nature of impurity. Where these colours are sufficiently deep, they destroy the optic characteristics of the mica; but even when they are only very pale it is seen that such mica, after heating, is much less active in polarized light than when in the normal state. Thus the micaceous mineral is more or less affected according as it is more or less developed towards muscovite, which is not so altered by moderate ignition, its colour and polarization-tints being not perceptibly influenced. In this manner we are enabled to make very instructive comparisons between slates in various stages of evolution.

It is of interest to note that this test applies also to the new micaceous mineral of the clays and shales. I described (Geol. Mag., April, 1891) the results of some very careful levigations carried out on a typical "fireclay," and stated that, in the finest parts of the products obtained, a considerable proportion consisted of very minute flakes of a pale yellowish or greenish mineral, most of which could only be well seen when mounted in water. I consider that this portion of the products largely represents the new mineral formed in the clays and shales in question.

If it be heated to redness, and then mounted in balsam in the

[1] There is no harm in here reiterating a caution as to the necessity of *very thin* sections, this being especially important for those cut from dehydrated specimens. Personally, I have never seen any made by English cutters which are of the least value for studying this class of rocks. It is decidedly a case of things "made in Germany" being better! The vagueness and indistinctness of many descriptions given of slates, etc., are well accounted for when one sees the sort of paving-slabs which have often done duty as "thin sections," and when one sees them mounted on such thick glasses, and covered with such thick covers, that no use of higher powers or proper illumination is possible.

manner described in the paper referred to, it is seen to have taken on quite a reddish tinge, to be more opaque, and quite easily seen even in its minutest flakelets.

I have endeavoured to ascertain something as to the chemical composition of this new micaceous mineral in clays and shales; but, for obvious reasons, it is a rather unsatisfactory task. I took the two finest portions, called A and B in my former description of these levigations, made one sample of them, and carefully determined in it the percentage of several of the constituent bases.

In these finest slimes there takes place a concentration, not only of the new micaceous mineral, but also of a large proportion of the rutile-needles, anatase crystals, and ilmenite-flakes of the original material; also of a certain amount of epidote in small grains and crystals, some very fine quartz-powder, and the bulk of the organic matter of the fireclay. One can only make a rough estimate as to the quantity of these things which may be present in the levigated slimes, but, after much examination, I consider that it is safe to say that there is 25 per cent. of material other than the micaceous mineral.

Making an increase, in this proportion, in the actual figures found by analysis, the micaceous mineral will contain—

	per cent.
Potash	4·62
Soda	1·16
Magnesia	2·94
Alumina	32·31

A small portion of the alumina will be due to epidote, to which mineral we may also ascribe most of the lime present in the material (0·90 per cent.).

If we take the figures for the alkalies and magnesia, and approximately for the alumina, and if we consider that with them must also be included a good deal of ferrous oxide, some ferric oxide, and several per cent. of water, we get as near an idea of the constitution of the bases of this complex micaceous mineral as the conditions of the case allow us to obtain; and we see how it is that such a substance, under other conditions, gives rise to a mixture of a mica, more or less developed to muscovite, and of chloritic minerals.

We get this crystalline development of slates, as before remarked, in very varying degrees, and there are rocks of this class, of which the actual condition is at present universally accepted as being due to "regional" metamorphism only, in which the mica has really, so far as can be made out, become all *muscovite*.[1]

If, now, we look at slates in the neighbourhood of intrusive

[1] It may very likely be the case that in some slates, in which a larger proportion of soda than usual is present, the mica formed is largely paragonite. And in other cases there may be a mixture of muscovite and paragonite, or some mica may result which is chemically intermediate between the two. It would rarely be possible to make quite sure of this; but in any case the exact nature of this regenerated mica would not affect the considerations involved, and for convenience we may speak of it in general as muscovite.

igneous masses, we find that here, too, a development of the mica and a separation of chloritic matter have taken place, with a more or less considerable advance in the crystalline structure of the rock, up to very high stages indeed, even when none of the special "contact-minerals" are yet formed.

The consideration of these different cases brings us face to face with the most interesting, and as yet quite unsolved problem, as to how far such rock-development can be shown to go without calling in the aid of "contact-metamorphism,"—the only agency of which we really *know* that it is capable of carrying the crystalline development of these sedimentary rocks to its highest degree. There are three agencies by which we may assume that such crystalline slates or phyllites may be produced, and in many cases we may have very little or no *direct* proof or evidence as to which of them has been the cause. These three agencies are dynamic action, contact-action, and finally another action which is neither dynamic nor contact, but is simply due to long-continued submission to depth-temperature and pressure in deeply-buried sediments.

As regards the first of these agencies, the dynamic, it is, perhaps, really not at all possible to consider it alone. In all rocks which have been subjected to it, we must take into the question the amount of influence which the *third* agency has possibly exerted, both previously to, and concurrently with, the actual dynamic action.

Then, again, contact-action will often be due, and in its most striking developments will probably always be due, to the effects of intrusions on rocks which have already been a long time under the influence of more or less considerable depth-conditions, and which have undergone whatever changes these conditions may be capable of causing in them.

No problem of petrology is of deeper and wider interest than that involved in the question here concerned; none demands more careful study or more freedom from hasty bias; and none has been more prejudiced by immense and authoritative generalizations on insufficient data.

One point, I think, is worthy to be insisted upon. It is of the greatest importance that investigation of the higher phases of development of these rocks should be based, first of all, upon a minute study of the lower forms of them in clays and shales, so as to understand as fully as possible what it is from which the evolution starts; what is the condition, chemically and mineralogically, into which the sediments have passed at the earliest stage of their history at which we can begin to regard them as having become rock-bodies at all.

Taking, firstly, dynamic action (but bearing in mind what has just been said as to its probable association in all cases with other influences), the tendency has been, among many geologists, to accept it as capable of causing almost anything in the way of crystallization and regeneration of sedimentary materials. It has even been made to include, as it were, other agencies within it, contact-metamorphism

having been explained as due simply to the *dynamic* effects which have accompanied igneous intrusions. This may perhaps be regarded as the high-water mark of enthusiasm in this direction, and would find but few followers now, extreme views as to dynamic metamorphism being apparently much less in favour than they were a short time since, and many of us who were to a considerable extent believers having become rather more sceptical.

But dogmatic opinion in an opposite direction is quite as much to be deprecated. It is always desirable to bear in mind that though we may have to consider any number of cases of highly-developed crystalline slates, phyllites, and schists, demonstrably derived from sedimentary deposits, and equally demonstrably affected in a high degree by dynamic action, we are not yet, therefore, in a position to assert that the crystalline and mineralogical development of those rocks is *caused by* this dynamic action. It may conceivably be due to the contact-action of concealed igneous masses, or it may be due to the other agency which we are considering. The dynamic action may have accompanied either of these, and possibly assisted them, but may have had really very little, if any, share in the causation of the effects with which we are now concerned. And on the other hand, it is perhaps still more important to give due weight to the evidence of those cases in which we have dynamic action of the most intense description, and yet find that the rocks so affected, while chemically and mineralogically closely resembling those just considered, are very much less developed, and have, indeed, in this special direction very little to show for the work done on them.

(*To be continued in our next Number.*)

VI.—*Archæodiadema*, a New Genus of Liassic Echinoidea.

By J. W. Gregory, D.Sc., F.G.S.

OWING to the absence from England of any marine fossils of Triassic age—except the few obscure shells described by Mr. R. B. Newton[1]—the Lias yields the first English representatives of the Neozoic Echinoidea. The fauna is not rich in species, and as a rule the specimens are small; but it is of interest, as its members are primitive in character, and as they foreshadow many of the main lines of evolution followed by the rich Echinoid faunas of the Oolites. Some months ago Mr. Beeby Thompson showed me some specimens from the Upper Lias of Northamptonshire, which form an interesting addition to the primitive types of Liassic Echinoidea; they belong to a new genus, which is the simplest known form of the Diadematinæ, and occupies the same relation to the remaining members of that subfamily that *Eodiadema* occupies to the Orthopsinæ.

Archæodiadema, nov. gen.

Diagnosis. — Diadematidæ Diadematinæ[2] with the following characters:—

[1] R. B. Newton, "Note on some Molluscan Remains lately discovered in the English Keuper": Journ. Conch., vol. vii, Nos. 11 and 12, 1894–5, pp. 408–13.

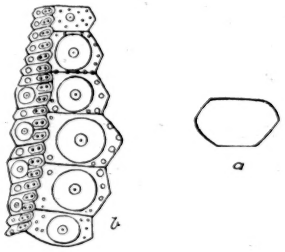
[2] P. M. Duncan, "Revision of the Genera and Great Groups of the Echinoidea": Journ. Linn. Soc., vol. xxiii, 1890, pp. 58–9.

Test small, turban-shaped.

Apical system large, area equal in width to half the diameter of the test; arrangement of plates unknown.

Ambulacra of simple, primary plates near apical area; of compound plates formed by union of three primary plates at ambitus. The pore-pairs are in a straight, single series. Ornamented by granules and a small primary tubercle on some of the ambital plates; the primary tubercles are perforate and non-crenulate.

Interambulacra of plates which, in comparison with the size of the test, are high and large; the plates are unituberculate, each bearing a single, primary tubercle, which is perforate and non-crenulate.



Distribution.—Lias: England.

Type Species.—*A. Thompsoni*, n.sp.

Affinities.—This genus is based on some small but admirably preserved specimens from the Upper Lias of Higham Ferrers, in Northamptonshire. They were collected by that indefatigable worker on the Midland Lias, Mr. Beeby Thompson, F.G.S., by whom they have been presented to the British Museum.

It is clearly a member of the family Diadematidæ as defined by Duncan. Of the four subfamilies of that great group, it differs from the Orthopsinæ by having compound plates in the ambulacra, and from the Diplopodinæ and Pedininæ by having the pore-pairs in simple vertical series, instead of their being biserial or triserial. The specimens agree, on the other hand, in all points with the Diadematinæ. Among this subfamily the new genus is most nearly allied to the genus *Diademopsis*, from which it differs by two characters: 1st, the pores in *Diademopsis* are either crowded or occur in arcs near the peristome; 2nd, the interambulacral plates in the same genus are lower and broader, and each bears two primary tubercles, which are lower and smaller than those of this new form. It differs from *Hemipedina* by the same characters, for the intimate affinity between this genus and *Diademopsis* is now generally admitted. In some respects *Archæodiadema* resembles *Microdiadema*, Cotteau, from which, however, it differs by three very definite characters: 1st, the apical area is equal to half the diameter of the test, instead of about one-fifth of the diameter; 2nd, the tubercles are perforate and non-crenulate, instead of perforate and crenulate; 3rd, there is

one row of primary tubercles in each series of interambulacral plates, instead of several series.

The only Echinoid known to me, in addition to the type species, which may be referable to this genus is one figured by Quenstedt[1] as *Echinopsis nattheimensis*, which Desor and De Loriol-Lefort[2] have refigured as a *Hemipedina*. The figure of the latter authors shows the pore-pairs in a single series to the peristome, and if this be the case, then the species must enter the new genus. But these authors also showed some species, such as *Hemipedina elegans* (Des.), with the same character; and these, according to the more detailed figures of Cotteau,[3] have the normal arrangement of *Hemipedina*.

The small size and primitive characters of the specimens render it necessary to consider whether they are only young *Diademopsis*; but the specimens seem to be fairly abundant, and yet are generally of about the same size; the whole appearance of the Echinoids suggests that they are adult.

Archæodiadema Thompsoni, n.sp. (See Woodcut, p. 318.)

Diagnosis.—*Test* small, turban-shaped; sides tumid; abactinal half depressed; actinal half somewhat conical; circular.

Apical system large, regularly pentagonal; arrangement unknown.

Ambulacra narrow, inconspicuous. About four fair-sized primary tubercles in a vertical row on the ambitus; these gradually decrease into small secondary tubercles above and below.

Interambulacra of vertical series of from six to nine plates; the scrobicular circles are complete above, but incomplete at the ambitus. There is one row of primary tubercles, and the number of granules is small; these mainly occur in a band down the middle of interambulacrum.

Peristome large, circular, with conspicuous branchial slits.

Dimensions.— Diameter, 6 mm.; height, 3 mm.; diameter of apical area, 3 mm.; diameter of peristome, 3 mm.; width of ambulacrum at ambitus, 1 mm.; width of interambulacrum at ambitus, 3 mm.; number of primary ambulacral plates in vertical series, 19; number of interambulacral plates in vertical series, 7.

Distribution.—*Cerithium* beds or Lower *Leda ovum* beds[4] of Upper Lias: Higham Ferrers, Northamptonshire.—British Museum Coll. Presented by Beeby Thompson, Esq., F.G.S.

VII.—Notes on Professor Bonney's "Ice-Work."—Glen Roy.

By Dugald Bell, F.G.S.

Besides his numerous papers intended for experts in geological science, Professor Bonney is to be congratulated on the lengthening list of his more popular writings on the subject.

[1] Quenstedt, "Handb. d. Petref.," 1852, p. 582, pl. xlix, fig. 37; also in "Petref. Deutsch.," Bd. iii, 1874, p. 349, pl. lxxiv, figs. 10, 11.

[2] Desor and De Loriol, "Echinol. helvét.," 1871, p. 194, pl. xxxiii, fig. 3.

[3] Cotteau, "Pal. franç. Terr. jurass.," t. x, pt. 2; "Echinides réguliers," livr. ii, 1883, pl. cccxciii.

[4] Beeby Thompson, "The Upper Lias of Northamptonshire," part vi: Journ. Northampton Nat. Hist. Field Club, vol. v, 1888, p. 54; the section is described on p. 63.

A general notice of his recently-published volume on "Ice-Work" has already appeared in these pages.[1] The present writer desires, with all respect, to add a few notes on some points in which Scottish readers are more particularly interested.

In his preface, the author states that, in this book, he has "endeavoured to follow the example of a judge rather than of an advocate; that is, to sum up the evidence on each side of a case, and leave the verdict to the jury." He admits that, "like any such official," he has his "own view as to what the verdict should be, and this doubtless will be disclosed to those who can read between the lines." In other words, he does not claim that his summing-up is absolutely without bias; but that, as his opinion "has not been formed hastily or without experience," the bias is in the right direction. In such a case, it may safely be said, the assumed or ostensible office of judge is very apt to merge altogether into that of advocate, for extremely "thin partitions do their bounds divide." Indeed, we think, there are many parts of the book which are far more the work of an advocate—a very skilled advocate, we admit—than of a judge.

No doubt there are many things in all departments of science which are not yet settled, and which require careful revisal and restating from time to time. But the line of this "debatable ground" is constantly being carried forward; numbers of such disputed points are always being disposed of, and taking their place among the substantial additions to knowledge; so that, unless some new and unexpected evidence has emerged, further discussion of them becomes out of date and unprofitable. We think that at this time of day, a good many points in Glacial geology may be taken to be in this position—practically settled, and placed in the category of *Res Judicatæ*. Professor Bonney, however, reopens several of them, about which there can hardly be said to be, or to have been for many years, any question.

One conspicuous instance of this is with regard to the well-known "Parallel Roads" of Glen Roy.

"It is agreed," remarks Dr. Bonney, "that these 'Roads' are *beaches*"; but "the cause which brought the water to these levels is still a matter of dispute. By some authorities they are considered to have been formed by the sea when the land stood at a lower level than at present; the highest being the oldest, and the second and third marking pauses in the process of upheaval. By other authorities they are attributed to fresh water, and are supposed to have been formed on the shores of lakes which were held up by glaciers during some part of the Ice Age."[2]

The "dispute" is thus represented as still pending, one on which "authorities" are divided; the truth being that there has been little or no "dispute" on the subject for nearly thirty years, the advocates of the glacier-lake theory being generally considered to have proved their case, and the "authorities" being, for all that time, practically

[1] Geol. Mag., May, 1896.
[2] "Ice-Work," pp. 94–7.

ranged on their side. Agassiz and Buckland, twenty years earlier, Mr. Jamieson, Sir Charles Lyell, Sir Henry James, Sir Archibald Geikie, Dr. James Geikie, Professors Tyndall and Prestwich—Darwin also, who at first favoured the marine theory—have all in succession adopted and illustrated this view. What "authorities" can be named on the other side? Professor Bonney himself excepted, we are aware of none since the late Professor Nicol, of Aberdeen, who wrote on the subject thirty years ago.

Ten or twelve years before that time, Sir Charles Lyell, in the earlier editions of his "Manual," observed with regard to the formation of these "Roads"—"The problem is only solved in part; a large number of facts must be collected and reasoned upon before the question can be finally settled."[1] But seven or eight years afterwards so much progress had been made in this work, by Dr. Jamieson and others, that Sir Charles, reviewing the whole evidence anew, was satisfied that "the Glen Roy terrace-lines, and those of some neighbouring valleys, were formed on the borders of glacier-lakes."[2] We take Sir Charles to have been an ideal "judge" in geology; clear, impartial, painstaking, competent; always prepared to follow where well-tested evidence led. We ask, what has transpired since then that we should now be taken back to the point which he abandoned more than thirty years ago? Why should his later decision in the matter be ignored, the evidence on which it rested set aside, and the history of these "Roads" still spoken of as 'likely to remain among the controversial questions of geology,'[3] as if nothing had been attempted, nothing done, no fresh facts collected or additional light gained, for more than a generation?

It will be admitted that among the first merits of a good judge are precision in the citation of similar cases ("chapter and verse" being usually given), and clearness in distinguishing between those which bear directly on that in hand, and those which only affect it remotely, if at all. But even the "common juryman" can see that Dr. Bonney's "instances" are frequently of the vaguest and most unsatisfactory kind.

"The advocates of the marine origin," we are told, "call attention to the fact that terraces of a *rather similar* kind occur at *lower levels* in other parts of Scotland, especially on the western coast" (p. 97). Doubtless some one, to us unknown, has used the argument in this form (the italics are ours); but we wonder that Dr. Bonney should repeat it as of any value. The essential points to be stated are, *Where*, and at *what level*, are the "terraces" referred to; and then we may be able to judge how far they assist us in Glen Roy. Again, with regard to the difficulty, on the marine theory, of the uniformity of the subsequent re-elevation—it being "improbable that the whole valley, about ten miles long, would be uplifted to the same amount"—Dr. Bonney gives as the answer to this, that "in other parts of Scotland, terraces admitted to be of marine origin alter their level

[1] Fifth edition, 1855, p. 89.
[2] "Antiquity of Man," p. 264 (1863).
[3] "Ice-Work," p. 107.

but slowly" (p. 98). Nothing can be made of this without further particulars.—Once more, in noticing the difficulty that "no marine organism has been detected among the materials of the roads," Dr. Bonney gives the answer, without any indication of its insufficiency, that the objection "might be urged with equal force in regard to many of the terraces in Scotland . . . the marine origin of which is not disputed" (p. 99). For the third time, we wonder *what* terraces are referred to. We know of none admitted to be marine, though destitute of marine remains. And though this were so, we presume that laxity of inference in one case cannot be cited as justifying similar laxity in another.

The "sea-marks" in Norway are more than once alluded to by Dr. Bonney; but it is not asserted that they even approximately coincide with the terraces in Glen Roy; in reality, the highest of them is much lower than the lowest in that glen, and they are quite different in position and other essential respects, so that it is not apparent how they help the case. Why do not the Glen Roy terraces, if marine, extend along the present coast like those in Norway? Next, "the coast of Peru" is mentioned—a "far cry," indeed, from Lochaber!—and, finally, after this circuit, Moel Tryfaen, Gloppa, and "other localities," which, as Dr. Bonney is doubtless well aware, are all "in dispute" at present, and some of which, including Moel Tryfaen, are being largely given up as proofs of submergence.[1]

Coming to other difficulties which have been urged against the "marine theory," Dr. Bonney continues to indicate the "replies," in all cases, as if perfectly sound and satisfactory. Thus, "if these beaches have been formed by the sea, it is difficult to understand why they do not occur more generally"—[or rather, why they do not occur at all]—"in the neighbouring valleys, and in other parts of Scotland." This is a difficulty which Lyell thought had never been got over. But Dr. Bonney calmly continues: "To this it is answered, that there is *a beach* in Glen Gluoy, and *some traces* are found, *though at different levels*, in Glen Spean *and elsewhere*"![2] We turn to our fellow-occupants of "the box," to see what they think of this answer. It seems to us that the beach in Glen Gluoy, instead of lightening the difficulty, immensely increases it. That beach does not correspond with any of the terraces in Glen Roy, as it should certainly do, had both glens been alike occupied by the sea; it is higher than any of them. Why is this so? Why did not the sea form *as high* a line in Glen Roy as in Glen Gluoy, and as *many lines* in the one glen as in the other? Nor is anything gained by referring to terraces "at different levels" in Glen Spean; these are all part of the very phenomena under discussion, and are explained by one of the parties in the case as due to the same local cause. What is wanted are similar beach-lines *at similar levels* in many other glens of Scotland, which the sea, if it ever stood at that height, must have formed. Where are they? Dr. Bonney says they are "elsewhere"!

[1] See Dr. J. Geikie's "Great Ice-Age," 3rd ed., p. 371.
[2] "Ice-Work," p. 98. (Italics ours.)

But, it is added, terraces of this kind "are only formed under exceptional circumstances, and are accordingly local in occurrence" (p. 98). This is just what has to be explained, and what we think the "glacier theory" does explain. Can Dr. Bonney indicate what exceptional circumstances, in the event of a submergence, favoured the formation of these beaches in Glen Roy rather than in Glen Gluoy, and in many other glens nearer the coast and opening more directly on the sea? Why, for example, should these alleged sea-beaches not be found in the neighbouring Great Glen, which, in the event of a submergence, must have been powerfully acted upon by the sea; as also in the Tay valley, the Forth and Clyde valley, the Tweed, Annan, and Nith valleys, and others? We can see no answer to these questions.

Noticing again the discrepancy between the terrace in Glen Gluoy and the highest in Glen Roy, which "ought to agree" (the heads of the glens being only a few hundred yards apart), instead of the former being some 15 feet higher,[1] Dr. Bonney adds that "the facts stated merely require that the land in rising should be tilted slightly upwards towards the north, while it remained nearly at the same level towards the west" (p. 98). We are not aware that the roads have been observed to rise towards the north, or are appreciably higher in the upper part of the glen than in the lower. All the earlier observers and surveyors dwell on their "perfect horizontality"; but we know that later measurements show certain —after all, unimportant—deviations. Prof. Prestwich pointed out that instead of a perfect level, the roads are "slightly waved," forming partial "curves," there being a difference of a good many feet between the highest and the lowest points of each, bearing a very small proportion, however, to their entire length. "To all appearances," he admits, "they are perfectly level." Sir Henry James, the former Director-General of the Ordnance Survey, stated that they "deviate slightly from horizontality in those parts where streams from the mountains above have cut small watercourses through them"[2]—which is just what might be expected. Indeed, we think the marvel is that, in spite of the loose and sandy nature of the material, these remarkable lines are still so perfect and so nearly level. There is no evidence that we are aware of in favour of any "tilting to the north," nor do we think that the sudden difference of 15 feet between the terrace in Glen Gluoy and the highest in Glen Roy, "only a few hundred yards apart," can be so explained. Besides, Glen Gluoy lies to the *westward* of Glen Roy, where Dr. Bonney supposes the land to have "remained nearly at the same level."

The truth is that, while Dr. Bonney thus labours on these minor points, a greater difficulty is all the time placed before him, which he simply passes by—viz., the fact that each "road" coincides with a *col* or opening out of the glen in which it occurs. Why should

[1] We may here repeat the figures as an aid to the reader's memory. Terrace in Glen Gluoy, 1166 feet; those in Glen Roy, 1151, 1067, and 855 feet.

[2] Notes to the Survey Map of the district.

this be if these shelves were formed by the sea? The line in Glen Gluoy, so much higher than any in Glen Roy, corresponds with its higher *col*; the three in Glen Roy all correspond with openings out of that glen and Glen Spean into the greater valley of the Spey. Did the "pauses" in elevation, "during which the roads were made," vary in these glens, and not affect others at all? It is surely impossible to imagine that the degree of submergence, and then of re-elevation, had any reference to the height of these *cols*; or that these "pauses" happened to take place, in every instance, just when the sea reached their level!

This fact, in our humble judgment, is of itself conclusive against the "marine submergence" theory; and, indeed, constitutes, as Mr. Jamieson has remarked, a *fourfold proof* in favour of the alternative, or "lake-theory." It shows, we think, in the clearest manner possible, that these "roads" were due to a *local cause*—to this particular group of glens being at one time blocked to the level of their highest *cols*, and subsequently in a smaller degree, to that of the side-*cols*: and that then the water, the natural drainage of the glens, found egress successively by the lower outlets, as these became available for it.

REVIEWS.

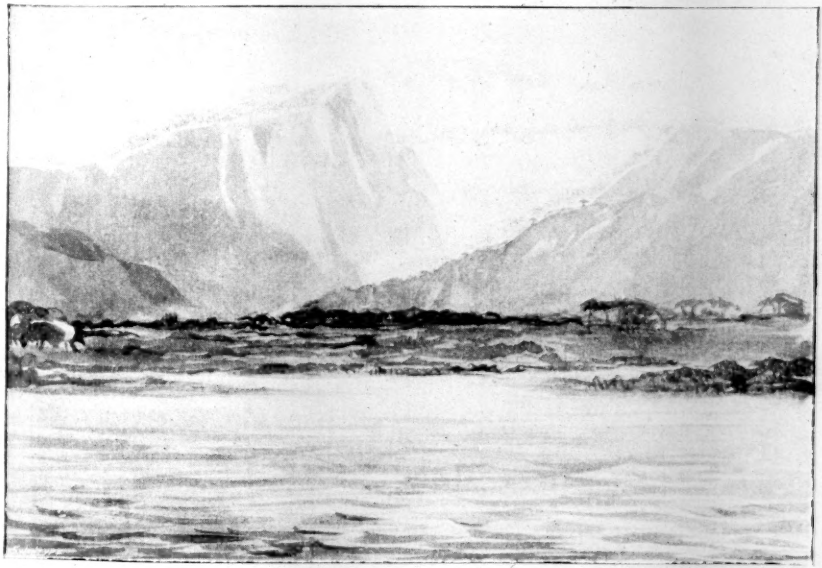
I.—The Great Rift Valley, being the Narrative of a Journey to Mount Kenya and Lake Baringo; with some account of the Geology, Natural History, Anthropology, and Future Prospects of British East Africa. By J. W. Gregory, D.Sc. (Lond.), F.G.S., F.R.G.S., F.Z.S., of the British Museum (Natural History). With Maps and Illustrations. Royal 8vo, pp. xxii and 422. (London, 1896: John Murray. Price 21*s*.)

(WITH PLATE XI.)

THE story of Dr. Gregory's adventurous journey to Mount Kenya and Lake Baringo, which the author has now placed before the world in the admirable volume just published by Mr. Murray, is not wholly unknown to many of us, for, on his return, he delivered an excellent evening lecture before the British Association at Oxford in August 1894, he also gave an account of his journey in a paper to the Royal Geographical Society, so that we have already learned from his own lips the main facts connected with that very plucky and (fortunately for the world of science) successful expedition. Anyone, however, who has a love of travel—whether he has heard Dr. Gregory tell his story or not—will take up this volume with interest, and will probably do, as we have done, *read* the book, instead of writing a review of it! For the story of British pluck and endurance, the dogged determination to overcome obstacles, however trying and apparently insuperable, always commends itself to the Anglo-Saxon, and makes his heart beat with pleasure and pride to claim such an one as a man and a brother.

In addition to the narrative, which of course occupies a large

THE SOUTHERN SHORES OF THE VICTORIA NYANZA (*after Geige*).



THE WESTERN WALL OF TANGANYIKA (*after Giraud*).

Two types of African Lake-Shores.

Reproduced by permission of Mr. John Murray, from Dr. Gregory's "Great Rift Valley."

proportion of the book, there is abundance of matter for the political economist, for the geographer, anthropologist, and the geologist. Botany and zoology have also gained by the varied novelties that Dr. Gregory has brought back. Some interesting cases of mimicry were observed by the author, one of which (drawn by Mrs. Gregory), representing a cluster of insects (*Flata nigrocincta*) grouped so as to resemble a flower-spike, forms a charming frontispiece to this volume.

Reverting to the title of the book, one is led naturally to seek for explanation of the term "the Great Rift Valley." We find an answer (on p. 3) where the author refers to Mr. F. Galton's statement, when discussing Mr. Thomson's paper on his journey through Masailand, namely, that the great depression or trough in which Naivasha and Baringo lie, is part of one "which begins with the Dead Sea, extends down the Red Sea, and ends at Tanganyika."

A study of the Lake-system of East Africa enables us to see clearly that the lakes are developed according to two absolutely different types. "Some are rounded in shape, as the Nyanza; others are long and narrow, as Tanganyika and the Nyasa." An examination of the lakes themselves shows "that the round lakes have low shelving shores, and that the long ones lie like fiords, between high, precipitous cliffs."

"The map shows us that these two types of lakes are not distributed haphazard, but on a definite plan. The long fiord-like lakes occur on two lines, which pass one on either side of the Nyanza and meet at Basso Narok (Lake Rudolf). Thence the line continues northward as a long strip of low land, dotted with lakes and old lake-basins, and sinking in places below the level of the sea. This extends to the southern end of the Red Sea, which repeats the structure of these fiord-like lakes on a larger scale: it is long and narrow, and, excluding some strips of coast deposits, has high, precipitous shores. From its northern end the Gulf of Akaba leads to another valley with similar characteristics, and from this the Dead Sea and Jordan valley continue the same type of geographical structure, till it ends on the plains of northern Syria.

"From the Lebanons, therefore, almost to the Cape there runs a valley, unique both on account of the persistence with which it maintains its trough-like form, throughout the whole of its course of 4,000 miles, and also on account of the fact that scattered along its floor is a series of over thirty lakes, of which only one has an outlet to the sea.

"This valley and its lake-chain are so different from anything else on the surface of the earth, that it is natural to ask whether different portions of it have been formed independently, or whether it was all formed at the same time and by the same process. The final answer to this question must be given by geology, but history affords us some useful hints. All along the line the natives have traditions of great changes in the structure of the country. The Arabs tell us that the Red Sea is simply water that did not dry up after Noah's deluge. The Somali say that when their ancestors

crossed from Arabia to Africa there was a land connection between the two, across the Straits of Bab-el-Mandeb. The natives of Ujiji, at the southern end of the line, have a folklore that goes back to the time when Lake Tanganyika was formed by the flooding of a fertile plain, rich in cattle and plantations. And at the northern end of the valley we have the accounts of the destruction of the towns of Sodom and Gomorrah.

"There is geological evidence to show that great earth-movements have happened along this Rift Valley, as it may be termed, at a recent date, which makes it distinctly probable that these traditions are recollections of the geographical changes.

"The structure of the Rift Valley has, therefore, very varied interests—geological and geographical, on account of its connection with the history of the eastern basin of the Mediterranean, and ethnographical, on account of its explanation of some of the best-known stories in our folklore. But it comes in contact with the problems of science on yet another side." "If all the air and water were removed from the earth, then the Rift Valley would present much the same aspect to the inhabitants of the moon as some of the larger of the lunar rills present to us. So the exploration of the Rift Valley has the additional attraction of offering the possibility of explaining the nature of some features in the surface of the moon."

From the days of Murchison in 1852 to the publication of Prof. Suess's memoir in 1891 writers in general on Africa seem to have held to the view of the great simplicity of Tropical Africa, and the long conservation of its ancient terrestrial conditions. If we turn to the Geological Map of British East Africa (p. 217) we shall see that a vast area is here covered with lava-flows on so gigantic a scale, that those of Vesuvius and Etna sink into insignificance beside them; they can only be compared with the great lava-sheets of America and the Deccan traps in India; the latter cover an area of 200,000 square miles, and those of the Western States of America have been estimated to occupy a tract as large as Great Britain and France combined. Richthofen and Geikie have suggested that these great lava seas were discharged from subterranean reservoirs through fissures possibly hundreds of miles in length, instead of through simple circular vents.

Dr. Gregory suggests that instead of a long line of fissure eruptions the plateau was probably traversed by a double series of lines of weakness crossing one another like a network, and that from the intersection of these lines numerous flows of lava would occur which would coalesce into continuous sheets. He describes these as plateau eruptions, rather than as fissure eruptions (p. 219). He then goes on to describe the mode of formation of the Great Rift Valley, contrasting it with the sinuous course and rounded slopes produced by denudation such as we are familiar with in England. "On emerging from the Kikuyu forests, we entered one which was straight in direction, and was bounded by parallel and almost vertical sides; its characteristic features were that its lines

were straight, and that its angles retained some of their original sharpness, for the direct action of faults and earth-movements still dominated the scenery. An hour after entering this valley, we reached the edge of the Great Rift Valley, which, like the former, must be directly due to earth-movements. Once the plateaux of Mau and Kikuyu were continuous across the site of the Rift Valley; a double series of north and south [faults] cut through the plateaux and allowed the block of material between them to subside. This left a great open Rift Valley (or, to use Prof. Suess's term, a 'Graben'). In this method of valley formation strips of country have fallen owing to a series of parallel cracks or 'faults,' and thus a valley has been formed with precipitous, and sometimes step-like sides. Such valleys have long been known in America, and the extraordinary steepness of their bounding walls may be seen in photographs of the Yosemite Cañon in California" (p. 220). We have dwelt rather more fully upon this part of Dr. Gregory's book, because he tells us that the desire to obtain more precise information as to the structure and origin of this Great Rift Valley was the main reason for his undertaking the journey described in this volume.

We commend Dr. Gregory's book most highly for its many-sided and suggestive views on a great variety of subjects, which are most ably discussed, and with a freedom of opinion and an absence of prejudice truly refreshing. We were much struck by the author's remarks that much of the political trouble in East Africa has arisen in consequence of our interference with that most ancient and well-recognized institution of slavery, which has doubtless been maintained by the Arabs for more than 3,000 years in the country, and could not be interfered with save by provoking the deadly hatred of this most powerful and intelligent race. "We have tried to destroy that which was an integral part of the social system of the ruling race, without realizing how vast a cavity would be produced, and how fatal it would seem to them.

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"At Melindi, at Mambrui, and Magarini, in fact all along the coast, extensive plantations are being abandoned owing to the impossibility of obtaining sufficient labour. The Arabs see their property being ruined, and are naturally hostile to British rule." . . . . . "The system of slavery in East Africa is really that of serfdom, and has been as necessary in the development of the country as feudalism was in Europe. Under the laws now in force the slaves will gradually die out and be replaced by freemen, and the change had far better come slowly than by a sudden revolution" (p. 380).

We must now bid the author adieu. We advise those who would enjoy a delightful and attractive volume to procure Dr. Gregory's charming book and read it for themselves.

By the kindness of Mr. John Murray we are permitted to reproduce on our Plate XI two types of African lake-shores, namely, that of Victoria Nyanza and the western wall of Lake Tanganyika, both taken from Dr. Gregory's work, p. 3.

II.—The Students' Lyell: a Manual of Elementary Geology. Edited by John W. Judd, C.B., LL.D., F.R.S., Professor of Geology, and Dean of the Royal College of Science, London. With a Geological Map and 736 Illustrations in the text. 8vo, pp. [24] and 636. (London, 1896: John Murray. Price 9*s.*)

THE editor of the students' textbook before us says—"The writings of Sir Charles Lyell occupy so undisputed a position among the classics of science that no apology is needed for the issue of the present work." Still the question may not unnaturally be asked what is the claim, what is the secret charm, of Lyell's writings which have attracted men of science and the public so strongly to accept his teachings, and even now, after he himself has passed away more than twenty years, his name is still a talisman to the seeker after geological truths, and his deductions are still held to be the guiding principles of our science.

If we look carefully into our Lyell we shall find that the writer is not only the historian and teacher, but he is also the observer and the inquirer. He takes us with him and shows us the action of rain and rivers on the surface of the land; the formation of river-valley terraces and deltas; the action of the sea, the wasting of cliffs, the formation of shoals and sandbanks, and the transport of materials along our coasts. We can pry with him into the extinct craters of the Auvergne or watch the still active volcanoes of Etna or Vesuvius. We learn from him the effects which have been brought about by the upheaval and foldings of the earth's crust, and the changes produced in the configuration of our continents by the agents of denudation during the gradual elevation of the land, and subsequently by the slow but untiring efforts of those subaerial agents ice, frost, snow, rain, and rivers, through vast periods of time over the broad surfaces of the earth.

Under Lyell's guidance we are led step by step from the operations of Nature now taking place around us, to reason upon the condition of the earth's surface in past ages, how these earlier physical changes were brought about, and what was their effect upon climate and life.

As we pursue our inquiry further and further back into the past, we perceive that, notwithstanding the numerous changes which our earth has undergone, and the appearance and disappearance of some entire groups of organisms, other persistent types have survived, often but little modified through the lapse of vast eons of time down to our own day. The conclusion is strongly pressed upon us that we are not dealing, as the earlier writers supposed, with a series of detached and isolated geological events or periods, each separated from the other and heralded by a huge catastrophe which swept away all pre-existing life and was succeeded in each case by a brand-new creation of its own. We now know that notwithstanding the varied changes of land and sea conditions which our earth has witnessed, there never was a period of total extinction of life since the first organic beings made their appearance on our planet, but

that the seeds of living organisms have persisted through all ages from the dawn of that life in pre-Cambrian times down to the present day.

It is no doubt largely due to the doctrine of evolution which Lyell has applied to geology, and to his sound methods of reasoning, based upon the study of the phenomena of existing Nature as furnishing us with the safest interpretation of what has taken place in the past history of our earth, that has given to his writings their worldwide reputation and their greatest charm.

In looking back upon the past history of the "Students' Elements," as it was formerly called, we shall only be enhancing its value by mentioning that its previous editions received, in addition to the hand of Lyell himself, the labour of the late Prof. P. M. Duncan, Mr. S. V. Wood, David Forbes, as well as of Robert Etheridge and Prof. T. G. Bonney, so that its reissue under the able editorship of Prof. Judd ought to assure for it a further profitable and protracted term of existence. The introductory chapter, dealing with geology in relation to other physical sciences and the causes which have retarded the progress of geology, is new and gives an interesting review of the science from the pen of one who is daily engaged in its exposition.

The illustrations are mostly excellent, and include not only 136 figures added since the last edition, but also a carefully prepared and coloured geological map of England and Wales as a frontispiece. The last six pages, devoted to appendices of living forms, should be carefully revised in a new edition. By the adoption of double columns and smaller type for the matter at the end of each chapter, much additional information has been introduced without enlarging the work more than by about 14 pages, nor has the price been increased.

We wish the work every success, and feel sure that its sale will be as large and its merit as lasting as the remembrance of the name of Lyell himself.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 27th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that a portrait in oils of the late Prof. Huxley had been presented to the Society by Sir John Evans, K.C.B., For.Sec.G.S.

The following communications were read:—

1. "On the Pliocene Deposits of Holland, and their Relation to the English and Belgian Crags; with a Suggestion for the Establishment of a new Zone 'Amstelien,' and some remarks on the Geographical Conditions of the Pliocene Epoch in Northern Europe." By F. W. Harmer, Esq., F.G.S.

The author draws attention to some papers by Dr. J. Lorié, of Utrecht, describing the strata met with in some deep borings in Holland, which show that the Newer Pliocene is in that country nearly 500 feet thick, and that it has been depressed more than 1000 feet below its original position. He inquires whether this subsidence can be connected with the elevation of the Older Pliocene in Belgium and Kent, and how far these earth-movements can be traced in East Anglia and influenced the deposition of the English Crag.

He gives particulars of the alterations in level which have taken place during and since the Crag period in England and on the Continent, showing that the two movements of upheaval and subsidence have much in common, and especially that they regularly increase in degree to the north and south respectively.

He gives a map showing the extension of the Diestien deposits of Belgium, and their probable connection with the Lenham Beds, and opposes the view of M. Dollfus that the Diestien sea was closed to the south, though the connection with it was probably cut off by the elevation of the southern part of the area at the close of the Diestien epoch, which also caused the Scaldisien sea to retreat to the north. At the close of the Scaldisien period the sea retired from Belgium altogether, no beds equivalent to the Upper Crag of England being known in that country. A similar alteration of the margin of the Crag sea can be traced in East Anglia.

He analyzes the fauna of the Scaldisien and Poederlien, and shows its close correspondence with that of the Walton bed, and the difference between it and the Upper Crag, which contains Arctic shells.

He describes the beds met with in the Dutch borings, regarded by Dr. Lorié as Diestien and Scaldisien, and their fauna, at some length. He concludes that a large part of them are altogether newer than the latter formation, and are equivalent to the Butley Crag, and he proposes for them the term "Amstelien."

He doubts whether any deposits of similar age to the Norwich Crag or Chillesford Beds have been met with in the *sous-sol* of Holland, which he considers became at that time a land-area; and he gives a section to show wherein his classification of the Dutch strata differs from that of Dr. Lorié.

The distinction between the divisions adopted by the author comes out more clearly from the consideration of the abundant and characteristic species only, of each of which he gives lists.

Although the Amstelien beds are more than 400 feet in thickness, they contain a shallow-water fauna, and were deposited in a basin which subsided *pari passu* with their accumulation.

In the map an attempt is made to show the limits of the sea of the Anglo-Dutch basin during the various stages of the Pliocene epoch.

It is suggested that the Chillesford Clay was deposited in an estuary through which the Rhine discharged into the North Sea, its presence in the western portion of the Pliocene basin being caused

by the elevation of Holland after the deposition of the Amstelien and a subsidence in Suffolk, which carried the Chillesford Beds over an area which was not covered by the Norwich Crag sea.

No equivalents of the Weybourn Crag or of the Cromer beds (Forest Bed series) have been found in the Dutch borings. These are to be referred to the Pliocene, as pointed out by Mr. Reid, but possibly some of the unfossiliferous pebbly gravel of Norfolk and Suffolk may be Pleistocene.

The Weybourn Crag marks a re-invasion of East Anglia by the sea; but previously to the deposition of the Cromer beds the southern margin of the Pliocene gulf had again retreated to the north, and an estuary, similar to that of the Chillesford Clay but situated farther east, received the waters of the Rhine, which brought down the drifted remains of mammalia and some southern mollusca.

The newest portion of the Cromer deposits is of an Arctic character, and seems to show that no great interval separated the Pliocene and the Pleistocene periods.

A second subsidence of the Dutch area took place in Pleistocene times; the Glacial and post-Glacial beds being 600 feet thick under Amsterdam. No Till or contorted Drift similar to the deposits occurring in East Anglia and in the district north-east of the Zuyder Zee has been met with in these borings. The glaciation of Holland proceeded from the Baltic, and not from Norway, and the Baltic ice does not seem to have reached the Dutch coast; still less could it have travelled thence in the direction of East Anglia.

The two prominent physical features of the Pliocene period were the Rhine and the basin of the North Sea. The hypothesis of a permanent basin with shifting shore-lines, in contiguity to which the shallow-water deposits of the Upper Crag were deposited, seems to agree with all the facts of the case, and to throw light on the geographical conditions of the Pliocene epoch.

2. "The *Lingula*-Flags and Igneous Rocks of the Neighbourhood of Dolgelly." By Philip Lake, Esq., M.A., F.G.S., and S. H. Reynolds, Esq., M.A., F.G.S.

The area dealt with in this paper lies south and west of Dolgelly, between the Arthog road and the hill called Mynydd Gader, which lies in front of the precipices of Cader Idris. The stratified rocks belong to the Middle and Upper *Lingula*-Flags and Tremadoc Slates. The Middle *Lingula*-Flags (Ffestiniog Series) consist of bluish slates with grit-bands containing the usual *Lingulella*, passing into Upper *Lingula*-Flags (Dolgelly Series) consisting of dark slates with *Orthis lenticularis*, *Parabolina spinulosa*, etc., and containing two andesitic lavas. These pass into the basal Tremadoc Slates, with *Dictyograptus flabelliformis*, surmounted by an upper volcanic series with rhyolitic lava. Subsequent intrusions of diabase occurred, of a laccolitic character, but of such a nature as to lead the authors to suggest the possible intrusion of the diabase along a line of unconformity in one case; there is, however, no newer rock above the diabase to indicate of what date the overlying beds would be if such unconformity occurred. It is further shown that the important faults in the area

were produced both before and after the diabase intrusions, and in one case the movement appears to have been in one direction before the intrusions, and in the opposite direction afterwards.

3. "The Kildare Inlier." By S. H. Reynolds, Esq., M.A., F.G.S., and C. I. Gardiner, Esq., M.A., F.G.S.

The area described in this paper is occupied by four prominent hills composed of Lower Palæozoic rocks rising as an inlier from beneath Carboniferous beds. The authors give the following succession of rocks in descending order:—

6. Green and grey micaceous grits and shales of Dunmurry.
5. Red and black shales.
   Gap: no exposure seen.
4. Limestones of the Chair of Kildare.
3. Contemporaneous igneous rocks.
2. Fossiliferous ash of Grange Hill House.
1. Green gritty shales (unfossiliferous).

Nos. 5 and 6 are referred with some doubt to the Llandovery Series, and perhaps also to higher series. The gap may conceal the uppermost beds of the Bala succession. The limestones of the Chair of Kildare are separated by the authors into four subdivisions of the same general age, and *Agnostus trinodus*, *Illœnus Bowmanni*, *Remopleurides longicostatus*, and *Cyphoniscus serialis* range throughout. The contemporaneous igneous rocks of Grange Hill and of the Hill of Allen are shown by the fossils found in the pyroclastic rocks to be of Middle Bala age. The lavas consist of basalts and andesites, which the authors separate into four groups distinguished by their lithological characters. Petrographical details of these various rocks are given in the second part of the paper. The age of the lowest beds which have not yielded any fossils is doubtful.

II.—June 10th. 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Foliated Granites and their Relations to the Crystalline Schists in Eastern Sutherland." By J. Horne, Esq., F.R.S.E., F.G.S., and E. Greenly, Esq., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The crystalline schists of Eastern Sutherland are traversed by great numbers of granitic intrusions, chiefly in the form of lenticular sills. These generally lie parallel to the foliation-planes of the schists, but transgressive junctions are also frequent. Thin seams of granite also occur in such abundance as to constitute with the schists a banded gneissic series; but these seams can often be seen to transgress the schistose folia, and even often to proceed from large masses of granite. The granites contain numerous inclusions of the schists which they traverse, such inclusions retaining, usually, the dip and strike of the surrounding rocks.

There are no chilled edges; and, moreover, the component crystals of schist and granite mutually interlock along the lines of junction.

The authors give an account of the foliation of the granite. In

some rare cases a foliation parallel to that of the schists traverses granite-veins. It is generally, however, parallel at once to the sides of the sill and to the foliation of the schists; and many of the structures are the remains of biotite-folia belonging to schists whose quartzo-felspathic elements have been incorporated with those of the granite. But many sills or veins, traversing the schists at various angles, are foliated parallel to the line of junction, and so discordantly to the structures in the schists; and foliated granites may even be observed to cut each other's foliation. These can hardly be anything but original igneous structures; but, if coexistent with the last-named, would be indistinguishable from it.

The country-rocks are various types of biotite-schist or gneiss, with quartz-schists at Kildonan, and a scapolite-limestone at Armadale. They are almost all holocrystalline, but it is certain that sedimentary rocks enter into the complex. The whole series is powerfully folded.

The granites increase in size and numbers north-westward from Kildonan, the intimate intrusive relations above described becoming more highly developed in the same direction. The schists, at the same time, become more and more highly crystalline, sillimanite also appearing in them. About Kinbrace they are coarse sillimanite-biotite-gneisses, with large striated felspars.

Igneous contact is not held to be the sole origin of metamorphism, though the cause which brought about the introduction of the granites has evidently also produced these high types of crystallization. The evidence of powerful movement which the schists everywhere present suggests that such movement was the initial cause of the whole series of phenomena. Movement recurred throughout, though all cataclastic structures (if such existed) have been wholly effaced by crystallization; introduction of granite being the final stage in the production of the complex, and a high temperature (as shown by the absence of chilled edges) being maintained to the very end.

With regard to the granites, the authors find it difficult to believe that they are wholly foreign matter, but remark that it is here necessary to observe the utmost caution.

2. "The Geology of the Eastern Corner of Anglesey." By E. Greenly, Esq., F.G.S.

The notes contained in this paper embody the principal results obtained during a survey of Anglesey on the six-inch scale.

The schists of the south-east of the island are succeeded unconformably by the slates of Careg Onnan, which appear to be separated by a strong unconformity from the Ordovician shales. The Careg Onnan slates appear (pending confirmation from other sections or direct fossil evidence) to be of pre-Cambrian age, and the author records the existence of sponge-spicules therein.

The ashy grits and bedded tuffs of Baron Hill, near Beaumaris, appear to have been moved somewhat from the ENE. along a thrust-plane. They are traversed by planes of mylonization, and are much broken and folded.

The Ordovician rocks consist chiefly of sparingly fossiliferous dark

shales and mudstones, but contain a group of volcanic tuffs on the horizon of the pisolitic ironstone.

The Carboniferous rocks appear to be about 700 feet thick, and contain conglomerates, sandstones, and shales, with plant-remains about the middle of the series.

The glacial striæ sweep round from SSW. at the north, to S.W. and WSW. at the south end of the district. In the Penmon area there is cross-hatching with a series running SSE., and it is suggested that this is due to fluctuations in the power of the Carnarvonshire glaciers to deflect the ice coming from the north, combined with the local influence of certain high ground.

3. "Seismic Phenomena in the British Empire." By M. F. de Montessus de Ballore, Captain of Fortress Artillery at Belle-Île-en-Mer. (Translated by L. L. Belinfante, B.Sc., B. ès L. Communicated by Sir Archibald Geikie, D.Sc., F.R.S.)

The author gives a brief outline of a plan that he has elaborated for studying Seismology. He has separated his work into four parts—I. The formation of an Earthquake Catalogue. 2. Refutation of the empirical laws previously enunciated. 3. Description of the globe from a seismological point of view. 4. Investigation of the characters which differentiate stable from unstable regions.

He gives a method by which the relative *seismicity* (or instability as regards earthquakes) of regions may be obtained and registered, and indicates some of the results which he has derived from his study, including the intimate relationship between instability and surface-relief, and the independence of seismic and volcanic phenomena.

The main part of the paper is a section of the third division of the author's work, and deals in detail with the earthquakes of the British Empire. In this part of the paper, the recorded earthquakes of the British Isles, India, Australia and New Zealand, British Africa, Canada, and various scattered possessions are described.

CORRESPONDENCE.

EOCENE BEDS AT BINCOMBE, DORSET.

Sir,—In your last issue (p. 247) Mr. Fisher says that if I had seen the section of Eocene beds at Bincombe open as he did, I might not have been at a loss to find room for the full thickness of chalk below them. But though I did not see the section, I had seen what was next best to it, and that was Mr. Fisher's account of it, showing the Eocene to be vertical. The chalk also is almost certainly vertical, or nearly so, between the Eocene and the mouth of the tunnel, where we are close to its base, but even so I was not able to pack in its full thickness, and had therefore to assume an overlap by the Eocene.

Mr. Fisher explains the occurrence of the Eocene gravels on the theory that they are wedged into the chalk by two faults, and do not occur as an outlier in the usual sense of the word. This

explanation involves certain difficulties. The shape of the outlier, as I still think it must be called, is roughly oval; the mass dropped in would therefore be cone-shaped. If it were a case of piping, which I do not think it is, this might be intelligible, but it is difficult to conceive a fault taking such a form. Nor is the difficulty lessened by the occurrence of several other small outliers in the immediate neighbourhood.

The structure seemed to me to be the same as that of the narrow strip of Tertiary beds near Lulworth, as Mr. Fisher suggests, except in one detail. In both cases the chalk, after running horizontally, or even dipping gently southwards, turns abruptly up so as to dip at 80° or more northwards; and in both, Tertiary beds, reposing naturally upon the Chalk, have shared in the flexure, and have been preserved from denudation in the elbow of the fold. But while at Lulworth the Isle of Purbeck fault coincides with the abrupt upturn of the strata, and thus runs between nearly horizontal Chalk and Eocene and nearly vertical Chalk, at Bincombe the Ridgeway fault runs at the base of the Chalk, and between it and Oxford Clay. I was not able to find any faulting there between the Chalk and the Eocene. That the abrupt upturn traverses the Bincombe outlier, we know by the fact that the gravels composing it are partly vertical, as shown by Mr. Fisher, and partly gently inclined, as proved by an exposure close to the western end of the outlier, where the chalk dips at only 15°. I quite agree with Mr. Fisher that in passing from south to north he is reading an ascending section in the Eocene strata.

A. Strahan.

Cardiff, 8*th June*, 1896.

THE AYRSHIRE "SHELL-BEDS."

Sir,—Many of your readers have doubtless been interested by Mr. John Smith's letter in your last number regarding his discovery of "interglacial shell-beds" at various heights in Ayrshire. Mr. Smith also read a paper on the subject at a recent meeting of the Geological Society of Glasgow.

While fully acknowledging Mr. Smith's great industry and perseverance in tracing out these "shell-beds," I would ask leave through your columns to repeat a *caveat* which I ventured to express at the meeting referred to, viz., against assuming offhand that the deposits are necessarily "interglacial," or true marine deposits *in sitû*. It appears to me that there are many hints and indications that they may be accounted for in another way, and that it will require further prolonged and careful observations before we can pronounce upon them with any certainty. There can be no doubt, to begin with, that the Clyde ice extended in great force over the lowlands of Ayrshire up to the feet of the Galston and Muirkirk Hills. Boulders of West Highland schists are found plentifully as far up as the neighbourhood of Loudon Hill, and in similar localities. The abundant deposits of sand, gravel, and silt in some of the side-valleys are just what might be expected in these circumstances. The crushed and fragmentary condition of the shells, or very many

of them, also suggests caution in drawing inferences. In some places they are found in the typical boulder-clay of the district.

I have since had the pleasure of seeing some of the sections in Mr. Smith's company. All I say is, there are abundant materials for investigation, and it will be well not hastily to leap to conclusions. *Festina lentè* is a good motto—especially as regards shell-beds.

Glasgow, 11*th June*, 1896. Dugald Bell.

P.S.—By the way, the term "shell-bed" is apt to be misleading. It may suggest a well-defined layer or band of shells, fairly well preserved; but the actual "find" is often only some fragments scattered here and there throughout the clayey or sandy deposit, as the case may be.

OBITUARY.

THOMAS BEESLEY, J.P., F.C.S.

Born March 28th, 1818. Died May 15th, 1896.

Thomas Beesley, who was born at Banbury, commenced business as a chemist and druggist in 1844 at Chipping Norton; two years later he succeeded to a similar business in his native town, and from this he retired in 1887. He was a man of great literary and scientific culture, expert as an analyst, and one who had a wide acquaintance with botany, archæology, and geology. During the past thirty years he gave especial attention to geology, and in 1872 communicated a valuable paper on the geology of the neighbourhood of Banbury to the Warwickshire Naturalists' Field Club (see Geol. Mag., vol. ix, p. 279). In the following year he acted with Prof. Morris in directing an excursion of the Geologists' Association to Banbury (Proc. Geol. Assoc., vol. iii, p. 197). The Lower Lias of Fenny Compton engaged much of his attention, and he made a fine collection of fossils, especially of Belemnites, from the zones of *Ammonites Jamesoni*, *A. armatus*, etc. (Proc. Warwick Nat. Club, 1877). Later on he gave an account of the sections exposed on the railway between Banbury and Chipping Norton; and at Easter, 1878, he acted in conjunction with Mr. Hudleston in directing an excursion of the Geologists' Association to Chipping Norton (Proc. Geol. Assoc., vol. v, pp. 165, 378). In 1883 he announced the discovery of a new local fossil, which he named *Discina Gunnii*; but as the fact was published in the *Banbury Guardian* of August 9th it can hardly be considered as a proper palæontological record. Kind-hearted and genial by nature, Mr. Beesley was ever ready to give help and information to those who sought it, and his memory will be cherished by all who had the happiness to know him.

H. B. W.

It is with deep regret that we have to record the death of Sir Joseph Prestwich, D.C.L., F.R.S., F.G.S., F.C.S., which took place early on the morning of the 23rd June, 1896, at his country house, Darent Hulme, Shoreham, by Sevenoaks, Kent, in his 84th year. For an account of his life and works, with an excellent portrait, see the Geological Magazine, Dec. III, Vol. X, June 1893, pp. 241–6.